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MANAGEMENT INFORMATION NEEDS ANALYSIS

FOR THE

DEPARTMENT OF HIGHWAY
STATE OF MONTANA

July 1981

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555 CAPITOL MALL
SACRAMENTO, CALIFORNIA 95814
Telephone: 916 441-7232 (California)
800 824-5080 (Other)

July 31, 1981

Mr. Gary J. Wicks
Director of Highways
Montana Highway Department
2701 Prospect Avenue
Helena, MT 59620

Dear Mr. Wicks:

This is a brief report on our study to identify organizational and management information needs for the Department. A Requirements Definition report has been prepared for each of the Department's major functional areas. Each report included recommendations as to how to proceed and the potential improvements and benefits that could be gained.

The attachments include the following:

+ Management Systems Priority Summary
+ A 4-year Development Schedule

The Maintenance Management System is by far the highest dollar priority to begin work on immediately. The Maintenance Division has the largest number of employees in the Department, so it's logical to better plan, schedule, and manage its size. The action that you took in reducing the maintenance budget by $2.5 million to $3.0 million was a good step to take and will be a true saving. Further dollar saving from a Maintenance System will no doubt be redistributed back into pavement betterment projects such as seal coating.

The next highest priority of systems to be developed is the Construction Management System. Your reduction in budgets here was a good move to take immediately. Further savings will be realized in time when more pavement rehabilitation projects begin to take precedence over new construction, and less staff per dollar of construction will be needed. Even after your budget reductions and the other cost reductions, this system is needed now to manage the second largest group of personnel in your Department.

I recommend that the Equipment Management System be undertaken so that it can become operational in parallel with Maintenance Management System since maintenance uses 83% of the 3,300 vehicle fleet. Here again the savings is large, but any saving in the budget should be kept and used to refurbish a fleet that needs to be systematically upgraded.

Of the Planning Support type systems, I urge you to immediately follow the recommendations in the Priority Programming Process report. The Department needs a Strategic Plan now to address the rehabilitation of the rapidly deteriorating road network. The priority arrays that the Planning and Research Bureau have recently developed should serve as the initial framework for a Pavement Management System that can be developed in the near future.

We have recommended that the Cash Forecasting System be developed to operate in a manual mode to start with and the steering committee concurred. The Preconstruction Management System can operate under PC/70 for the time being as the Department's design schedules will be simplified with less new construction projects and more pavement rehabilitation projects in the near term plans.

The Supply System can be well on its way operationally with just a few minor improvement recommendations.

The 60-day contract to develop these conceptual plans in EIGHT major areas of the Department has been a challenge. Without the excellent cooperation of you and your staff, the job could not have been completed.

I believe you have outstanding start on making this a No. 1 Department. The public will also appreciate your efforts in time by the fact that you are in the process of preserving a huge road-life investment. Thanks again for your confidence. We hope we can be of more service to you in the future.

Sincerely,

R. J. HANSEN ASSOCIATES, INC.

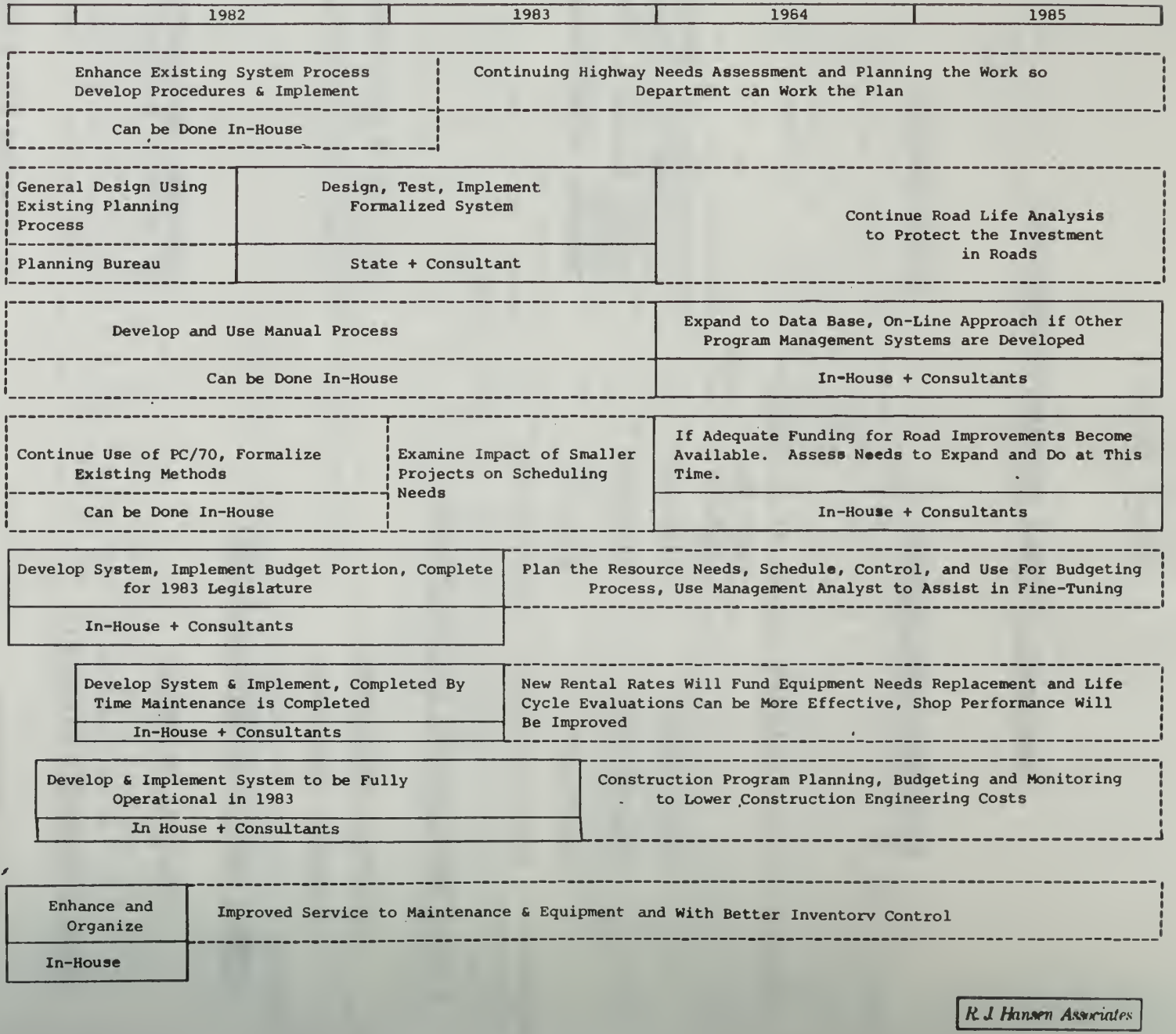
Robert J. Hansen
Managing Partner

RJH:mm
Attachments
cc: John Prebil, Deputy Director

MANAGEMENT SYSTEMS PRIORITIES/BENEFITS

RECOMMENDED ACTIVITIES		MAJOR BENEFITS
SYSTEMS TO BE DEVELOPED LISTED BY PRIORITY:		
	Cost To Develop	
1. MAINTENANCE	$450,000	UNIFORM LEVEL OF SERVICE AND BUDGETING PROCESS
2. CONSTRUCTION	$400,000	BETTER BUDGET & CONTROL PROCESS
3. EQUIPMENT	$250,000	IMPROVED FLEET MANANGEMENT
	$1,100,000	
SYSTEM PROCESSES TO BE IMPLEMENTED:		
PRIORITY PROGRAMMING		PROVIDES A STRATEGIC PLAN
PAVEMENT MANAGMENT		EXTENDS ROAD-LIFE INVESTMENT
DEVELOP MANUAL FORECAST METHODS:		
FINANCIAL PLANNING		IMPROVED INVESTMENT PLAN TO PROTECT ROAD NETWORK
ENHANCE EXISTING SYSTEMS:		
PRECONSTRUCTION		AN ON-TIME BID-LETTING SCHEDULE
SUPPLY		AN OPERATIONAL SUPPLY SYSTEM

A SUGGESTED MANAGEMENT INFORMATION SYSTEMS DEVELOPMENT SCHEDULE


1982
1983
1984
1985
PROJECT SELECTION, FORMULATION, PRIORITY
Enhance Existing System Process
Develop Procedures & Implement
Continuing Highway Needs Assessment and Planning the Work so Department can Work the Plan
Can be Done In-House
PAVEMENT MANAGEMENT
General Design Using Existing Planning Process
Design, Test, Implement Formalized System
Continue Road Life Analysis to Protect the Investment in Roads
Planning Bureau
State + Consultant
CASH FORECASTING FISCAL PLANNING
Develop and Use Manual Process
Expand to Data Base, On-Line Approach if Other Program Management Systems are Developed
Can be Done In-House
In-House + Consultants
PRECONSTRUCTION SCHEDULING & FUND MANAGEMENT
Continue Use of PC/70, Formalize Existing Methods
Examine Impact of Smaller Projects on Scheduling Needs
If Adequate Funding for Road Improvements Become Available. Assess Needs to Expand and Do at This Time.
Can be Done In-House
In-House + Consultants
MAINTENANCE MANAGEMENT SYSTEM
Develop System, Implement Budget Portion, Complete for 1983 Legislature
Plan the Resource Needs, Schedule, Control, and Use For Budgeting Process, Use Management Analyst to Assist in Fine-Tuning
In-House + Consultants
EQUIPMENT MANAGEMENT SYSTEM
Develop System & Implement, Completed By Time Maintenance is Completed
New Rental Rates Will Fund Equipment Needs Replacement and Life Cycle Evaluations Can be More Effective, Shop Performance Will Be Improved
In-House + Consultants
CONSTRUCTION MANAGEMENT SYSTEM
Develop & Implement System to be Fully Operational in 1983
Construction Program Planning, Budgeting and Monitoring to Lower Construction Engineering Costs
In House + Consultants
SUPPLIES SYSTEM
Enhance and Organize
Improved Service to Maintenance & Equipment and With Better Inventory Control
In-House

R. J. Hansen Associates

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2. EQUIPMENT

3. CONSTRUCTION

4. PRIORITY PROGRAMMING

5. PAVEMENT MANAGEMENT

6. CASH FORCASTING

7. PRE- CONSTRUCTION

8. SUPPLY

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R.J. HANSEN ASSOCIATES, INC.

MANAGEMENT AND INFORMATION SYSTEMS CONSULTANTS

MAINTENANCE

MANAGEMENT INFORMATION NEEDS ANALYSIS

FOR THE

DEPARTMENT OF HIGHWAY
STATE OF MONTANA

July 1981

FINAL REPORT

ON ORGANIZATIONAL AND MANAGEMENT PRACTICES

MAINTENANCE

STATE OF MONTANA

DEPARTMENT OF HIGHWAYS

Prepared by:

R. J. Hansen Associates, Inc.

July 29, 1981

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I. INTRODUCTION

The firm of Burke and Associates, Inc., in association with R. J. Hansen Associates, has conducted a review of the Montana Department of Highways Maintenance Division's organization and management practices. This final report documents our findings and makes recommendations that should result in significant improvements in management effectiveness.

1. PROJECT BACKGROUND

The Montana Department of Highways (MDOH) has maintenance responsibility for 9,392 two-lane miles of roadway of which 98% is paved. The Department's Maintenance Division directs the maintenance effort from headquarters in Helena through eleven field divisions located throughout the state.

Over the past five years, Maintenance Division managers have had to cope with increasing maintenance needs and decreasing resources. In response to these problems, associated with an aging network and double-digit inflation, Maintenance Division managers

are seeking improved ways to develop appropriate maintenance strategies, better define funding and resource needs, and manage operations more effectively.

Other studies and research support the Maintenance Division's contention that management improvements are in order. For example, in 1979, the Federal Highway Administration (FHWA) conducted an independent review and evaluation of maintenance management practices in Montana, Among other points, the FHWA report states that "there are variations in maintenance practices between (field) divisions," especially in striping, bituminous patching and crack sealing; "present reporting requirements are not producing the information needed for good management;" and there is "need for additional training" at all levels of management. The report goes on to recommend: "(1) updating and upgrading equipment; (2) more preventive maintenance, in the form of betterments; (3) a formal management program, including priorities, standards, and so on; and (4) improving reporting and budgeting procedures."

An earlier Legislative Audit Report (June 30, 1978) found no "unreasonable variations between divisions in the level of highway maintenance activities." But facts to support this finding were not presented. A later study, summarized in the Budget Analysis: 1983 Biennium, by the office of the Legislative Fiscal Analyst, cites a "lack of planning between other department areas; no uniform work plan and methodology within field divisions; insufficient monitoring and control by division administrators; and poor budgeting techniques." . . . "It is impossible to determine a reasonable funding level without a comprehensive maintenance plan."

In response to these calls for management improvements, the Montana Highway Department is interested in taking action within the next two to eight months, (As an alternative, we suggest that the Department take action in the very near future -- to provide as much time as possible for development program and budget procedures.)

2. SUMMARY OF RECOMMENDATIONS

Research performed by the consultant's staff, the Maintenance User Steering Committee and other study groups clearly indicates that there is need for a better management system for road maintenance. After reviewing a number of alternatives, the Committee concluded that a project to develop and implement an improved maintenance management system is not only feasible, it is essential to making changes that will ensure uniform, effective and economical maintenance of Montana highways.

Specific recommendations resulting from this research call for the development and implementation of a maintenance management system that:

- Defines appropriate levels of maintenance services;
- Employs "performance" or "program" budgeting techniques, in ways that are fully consistent with existing accounting and SBAS procedures;
- Uses specific standards for maintenance work methods;
- Establishes, on an annual basis, the needs for resources;

- Provides structured maintenance scheduling techniques; and
- Employs procedures for timely reporting of accomplishments and performance against an annual maintenance program.

Similar practices have not been implemented in Montana. But they can be -- with realtively nominal amounts of effort, resources and funds.

It is further recommended that Department managers consider concurrent development and implementation of systems for equipment management and road maintenance management.

Detailed recommendations relating to proposed system characteristics and plans of action are contained in Section III and V of this report.

3. SUMMARY OF BENEFITS

Research performed by the consultant and the User Steering Committee indicate that a project to develop and implement a maintenance management system would result in a number of specific benefits:

- Improved planning and budgeting - Performance (or program) budgeting procedures common to maintenance management systems establish specific relationships between effort levels (or service levels) and dollars. In effect, the procedures clearly document the planned use of funds -- a measure that encourages legislative support, as well as a sound basis for allocating funds throughout the Department.
- Uniform levels of service - Procedures developed during a maintenance management project will encourage consistent decisions regarding how much maintenance needs to be done. In effect, service levels can be standardized, throughout Montana.

- Improved resource allocation - Performance budgeting techniques also can provide the information needed to allocate labor, equipment and materials to each field division. These techniques provide facts that help optimize the numbers of people and the numbers and types of equipment needed to support maintenance programs, division by division.

- Increased productivity - Performance standards and field scheduling procedures implemented in many state-level agencies have brought about productivity increases ranging from 5 to 20 percent. These productivity increases generally have resulted in cost savings of around 7 percent of the total maintenance budget. Comparable cost savings, perhaps $2,000,000 per year, can be expected in Montana -- real dollars that can be funneled into needed preventive maintenance and betterment programs.

- Improved workmanship - The performance standards and scheduling procedures also will encourage better workmanship. The person directly in charge of field crews will know specifically what is expected, in terms of "how well" work is to be done.

- Better management information - Refinements can be made in current reporting procedures -- to provide timely information regarding work accomplishments, performance and cost, by maintenance activity and by object of expenditure.

- Reduced budget preparation costs - System budgeting procedures will reduce by at least 50 percent the amount of time and money it is taking to prepare maintenance budgets -- at a savings of about $50,000 per year.

Other system techniques will help level out the usual peaks and valleys in maintenance work loads, improve communication throughout the maintenance organization and provide a sound basis for long-term savings of Department resources.

The total estimated cost to develop and implement a maintenance management system is $466,450. The estimated ongoing cost following system implementation is $45,000 per year.

Clearly, the benefits, whether in annual cost savings of $2,000,000 or in improved management practices alone, far outweigh the cost of developing, implementing and operating an effective maintenance management system.

The costs and benefits of alternative approaches to the project are as follows:

Alternative	Estimated Dollar Benefit	Development & Implementation Cost	On-Going Cost
A "Stand Alone" Maintenance Management System	$1.5 to 2 Million/year	$426,450	$45,000
Retain A Management Analyst	$150,000/first two years	-	$85,000

II. SUMMARY OF FINDINGS

This section highlights some of the facts that point to problem areas affecting the Maintenance Division. It also identifies needed changes in current practices that will result in real management improvements. Finally, it focuses on design considerations that ensure compliance with top management's demands for a simple, easy to use, management system.

1. OVERVIEW OF CURRENT SYSTEM AND ORGANIZATION

Our overview of the current system and organization is based on interviews with key Maintenance Division personnel throughout the state, an examination of records and field visits to five of the eleven field divisions. The overview isolated a number of problem areas. Each of these problem areas serve to identify opportunities for management improvements:

- Decreased support for highway maintenance - Support for highway maintenance has been in general decline for the last five years. The chart shown in Exhibit 1 indicates trends for funding, staffing and material use.

- Variations in field division responsibility and support - Each field division has different needs in meeting maintenance service demands due to variations in climate, topography, road types and condition and traffic volume. The comparisons shown in Exhibit 2 indicate considerable variations among the eleven MDOH Divisions. All field divisions have a similar organizational structure. (A typical organization is diagrammed in Exhibit 3. Variations from this arrangement involve different numbers of field supervisors reporting to the maintenance supervisors. Also, in Bozeman, there is only one maintenance supervisor.)

- Variations in maintenance service levels - Maintenance service levels appear to vary considerably among (and within) the eleven field divisions. Work priorities are not uniformly established, field work procedures vary and resource allocations are not made using standardized criteria.

Exhibit 1

FIVE-YEAR MAINTENANCE TRENDS IN MONTANA

FUNDING SUPPORT

Maintenance Expenditures	FY 75-76	FY 76-77	FY 77-78	FY 78-79	FY 79-80
TOTAL DOLLARS	17,959,999	18,819,000	21,625,000	21,459,000	26,629,000
Maintenance Two-Lane Miles	8,635	8,687	9,216	9,283	9,382
Expenditure/ Two-Lane Mile	2,080	2,166	2,346	2,312	2,838
Expenditure/ *Two-Lane Mile (1979-80 $)	3,273	3,043	2,943	2,589	2,838

* Based on an assumed 12% average annual inflation rate for road maintenance commodities.

STAFFING TRENDS

	FY 75-76	FY 76-77	FY 77-78	FY 78-79	FY 79-80
FTE* Approved	**	**	669	669	669
FTE Actual	648	658	676	662	642
Two-Lane Miles	8,635	8,687	9,216	9,283	9,382
Two-Lane Miles per FTE Approved	**	**	13.78	13.88	14.02
Two-Lane Miles per Actual FTE	13.32	13.22	13.63	14.02	14.61

* FTE refers to full-time equivalent positions, including approximately 90 management personnel.

** Information not available.

Exhibit 1 (Cont'd)

ASPHALT USE

	FY 75-76	FY 76-77	FY 77-78	FY 78-79	FY 79-80
Total Annual Tons (Asphalt)	22,310	24,195	22,654	21,716	21,569
Maintenance Two-Lane Miles	8,635	8,687	9,216	9,283	9,382
Tons/Two-Lane Mile	2.58	2.79	2.46	2.34	2.30

GRAVEL USE

	FY 75-76	FY-76-77	FY 77-78	FY 78-79	FY-79-80
Total Cubic Yards	332,735	420,055	395,929	340,270	309,904
Maintenance: Two-Lane Miles	8,632	8,687	9,216	9,283	9,382
Cubic Yards/Two-Lane Mile	38.5	48.4	43.0	36.7	33.0

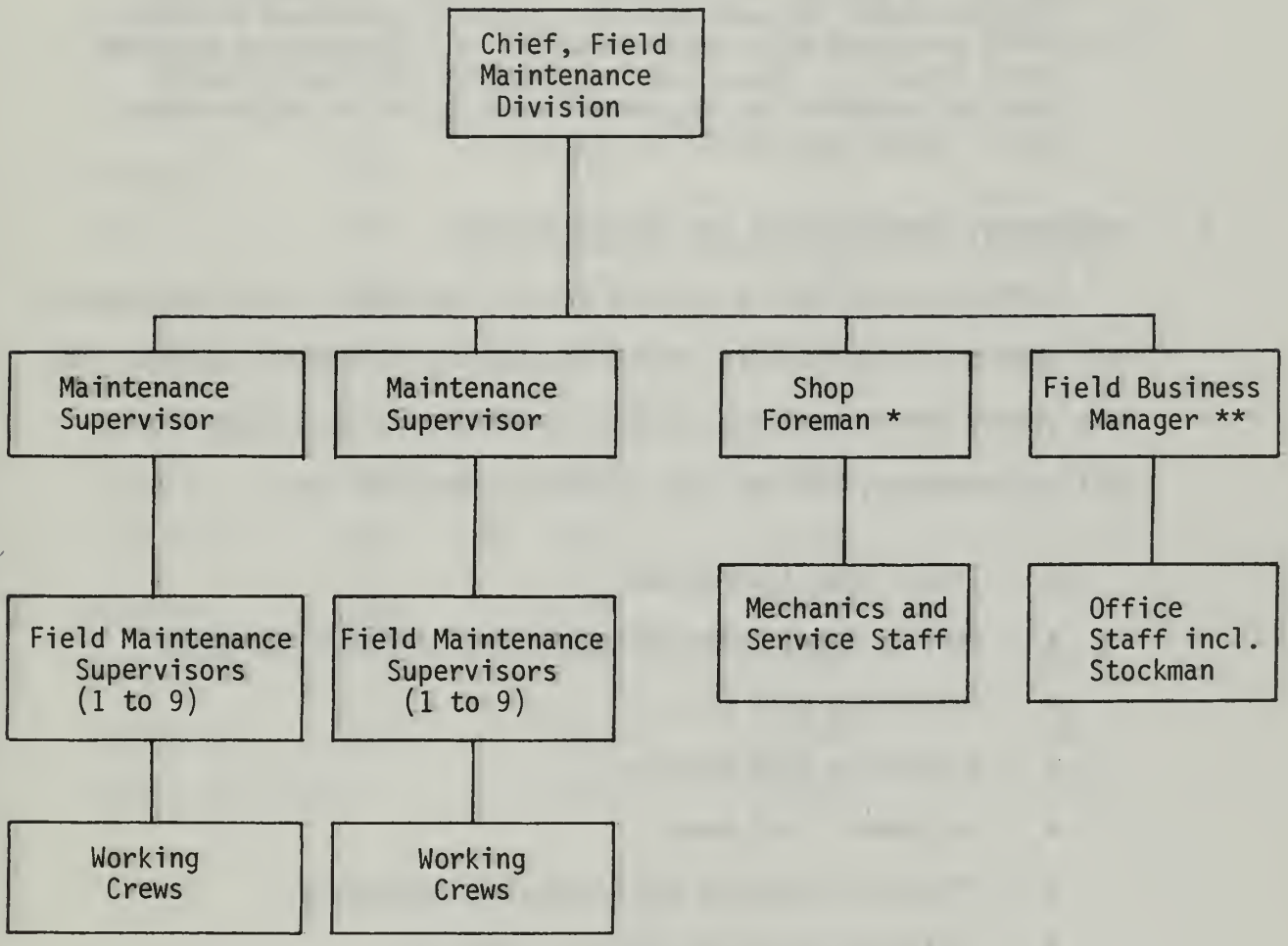
Exhibit 2

A COMPARISON OF MDOH FIELD DIVISION RESPONSIBILITY

Maintenance Division		Budget '81-'82	2-Lane Miles	No. of Crews	No. of Workers	Workers /Crew	Lane Miles Per Worker	Dollars Per 2-Lane Mile	Dollars Per Worker
MISSOULA	1120	3,676,298	976.1	17	80	4.7	24.4	3,766	45,954
KALISPELL	1220	3,073,804	679.0	18	71	3.9	19.1	4,527	43,293
BUTTE	2120	3,512,422	1,448.4	14	91	6.5	31.8	2,425	38,598
BOZEMAN	2220	2,661,213	756.6	10	43	4.3	35.2	3,517	61,889
GREAT FALLS	3120	2,591,172	851.6	14	54	3.9	31.5	3,043	47,985
HAVRE	3220	1,920,937	721.4	11	36	3.3	40.1	2,663	53,359
GLENDIVE	4120	1,626,806	670.8	7	29	4.1	46.3	2,425	56,097
WOLF POINT	4220	1,764,519	631.8	7	31	4.4	40.8	2,793	56,920
BILLINGS	5120	2,680,465	1,111.2	11	54	4.9	41.2	2,412	49,638
MILES CITY	5220	2,032,354	720.0	12	35	2.9	41.1	2,823	58,067
LEWISTOWN	5320	2,211,866	825.3	13	44	3.4	37.5	2,680	50,270
TOTAL:		27,751,856	9,392.2	134	568	--	--	--	--
AVERAGE:		--	--	--	--	4.2	33.1	2,955	48,859

Exhibit 3

TYPICAL FIELD ORGANIZATIONAL STRUCTURE



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* The Shop Foreman receives day-to-day direction from the Chief of the Maintenance Bureau. Technical direction comes from the Helena-based Equipment Division.

** Field business managers receive day-to-day direction from the Chief of the Field Maintenance Bureau. Technical direction comes from the Centralized Services Division.

Exhibit 4 shows the FY 81-82 budget requests for each field division, for hand and minor machine patching. As indicated in this exhibit, the cubic yards of patching material per paved lane mile varies considerably, from one division to another. (Some of the variations may be based on an inconsistent understanding of what is maintenance and what is betterment work.)

- Management information limitations - Data gathering efforts of the Maintenance Division are directed toward satisfying accounting needs. Work results, expressed in accomplishment-related terms, are not reported. Reports generated for the field divisions describe the amounts of all resources used and costs incurred. Also, many cost reports relating to equipment and material use lag actual work by six to eight weeks, due to manual data handling procedures.

2. IMPROVEMENT OPPORTUNITIES AND NEEDED ACTIONS

Current maintenance practices can be improved. Realizing improvement opportunities involves taking appropriate management action. The most urgent needs requiring action, as identified by Maintenance Division managers, and the User Steering Committee, are:

- Timely Cost Information
- Service Level Expectations versus Available Resources
- Accounting Data Use
- Accounting Data Accuracy
- Equipment Fleet Needs
- Effective Planning and Scheduling Procedures
- Staffing and Organization Inequities
- Training Needs
- Other Needs

Each need is described in detail, below.

Exhibit 4

PATCHING MATERIAL REQUEST COMPARISON

FY 1981-82

Maintenance Division	Code	Lane Miles of Bitum. Surface	Material Request CY	CY Mat./ Bit. Ln. Mi
Missoula	1120	1728	4,000	2.3
Kalispell	1220	1358	35,000	25.8
Butte	2120	2669	15,000	5.6
Bozeman	2220	1272	4,500	3.5
Great Falls	3120	1647	10,000	6.1
Havre	3220	1416	10,000	7.1
Glendive	4120	1342	10,000	7.5
Wolf Point	4220	1264	3,800	3.0
Billings	5120	2222	8,525	3.8
Miles City	5220	1398	22,600	16.2
Lewistown	5320	1651	16,000	9.7
TOTAL, ALL STATE		17,967	139,425	7.8

- Timely cost information - Timeliness of budget/cost status reports is a most significant need. Currently, cost status reports lag actual work by six to eight weeks for equipment and store items. The time lag results in a virtual shutdown of all material-intensive activities (sealing and heavy patching) from May 15 until July 1st, because field managers do not know if they have adequate funds to cover expenditures. This reduces the effective summer season by approximately one-third -- a truly significant problem for a snow belt state.

  Field divisions need to know their outstanding budget balances -- especially if cost accounting information is to be of any management value. Now, field division managers believe they are always subject to "surprise" cost figures. Also, given the fact that overruns of appropriations are illegal and considered a misdemeanor, field chiefs are compelled to operate very conservatively. They have to concentrate on cost control at the expense of providing maintenance service. Estimated cost underruns for FY 1981 were in excess of $2,000,000 statewide.

- Absence of service level expectations - There are no statewide service level guidelines which all field divisions are obliged to use. Furthermore, budget allocations and resources (labor, equipment and materials) are not distributed among the different field divisions in a manner consistent with uniform service-level demands. Statewide consistency of service levels is a reasonable goal that can only be realized when budget and resource allocations are made on the basis of planned maintenance service needs.

- Questionable accounting data use - Considerable time is spent by the field divisions gathering and preparing accounting data that is of questionable use. (Reports that were initiated for a specific purpose will too often be continued after their need has passed.) Time lags (as previously mentioned) prevent many other reports from providing the useful information for which they were intended.

- Questionable accounting data accuracy - Equipment cost data for maintenance (reported monthly on Form 905) is of questionable accuracy. Also, edit procedures are limited to checking for clarity and numerical accuracy. There are no checks as to whether or not charges reflect actual use patterns. (Daily equipment use reports, Form 901, which provided a more accurate record were eliminated from general field use.)

- Inadequate fleet support - The existing equipment fleet does not meet present-day maintenance needs. Replacement practices are not in keeping the fleet up-to-date, and as the fleet's average age increases, repair needs increase. Also, current work planning procedures do not identify the equipment needed to support planned work. Instead, the work performed is a function of existing equipment availability and capacity.

- Lack of standardized work programming and scheduling procedures - Work planning and scheduling procedures are not standardized and it is widely recognized that they need improvement. Currently, work is planned on a day-at-a-time basis. Major preventive maintenance operations are very difficult to plan in advance, mainly because construction project schedules are not realiable. As a result, Maintenance Bureau Chiefs who try to plan around major projects are all too often forced to abandon plans and assign crews to random routine work.

  Lacking definite work programs and recognized priorities, foremen lack direction in scheduling day-to-day operations. Furthermore, scheduling responsibilities are not clearly defined. There also is considerable variation in the way in which field operations are approached.

  Clearly, field divisions need well-defined long-range work plans and objectives if improved planning and scheduling procedures are to become a reality.

- Staffing and organization inequities - Organizational adjustments need to be made that will reduce current inequities in management's responsibilities. Specific problems that require attention include:

  + Field Division boundaries that do not provide an equitable distribution of responsibility and work load;

  + Support staffs that tend to concentrate their attention on former District Headquarters Divisions at the expense of the remaining outlying ones; and

  + Constraints on field operations flexibility, due to union contract limitations.

- Training needs - Skill development is needed for field crews in the areas of equipment operation and maintenance work methods. The supervisory staff needs training support in the use of new management and administrative procedures.

- Other needs - Other needs defined by the Maintenance User Steering Committee include:

  + Simplified stores inventory procedures;

  + Assistance in handling permits and encroachments;

  + Better Division shop and office facilities;

  + An updated maintenance manual;

  + Timely personnel transactions; and

  + Personnel for special research work.

3. SYSTEM DESIGN CONSIDERATIONS

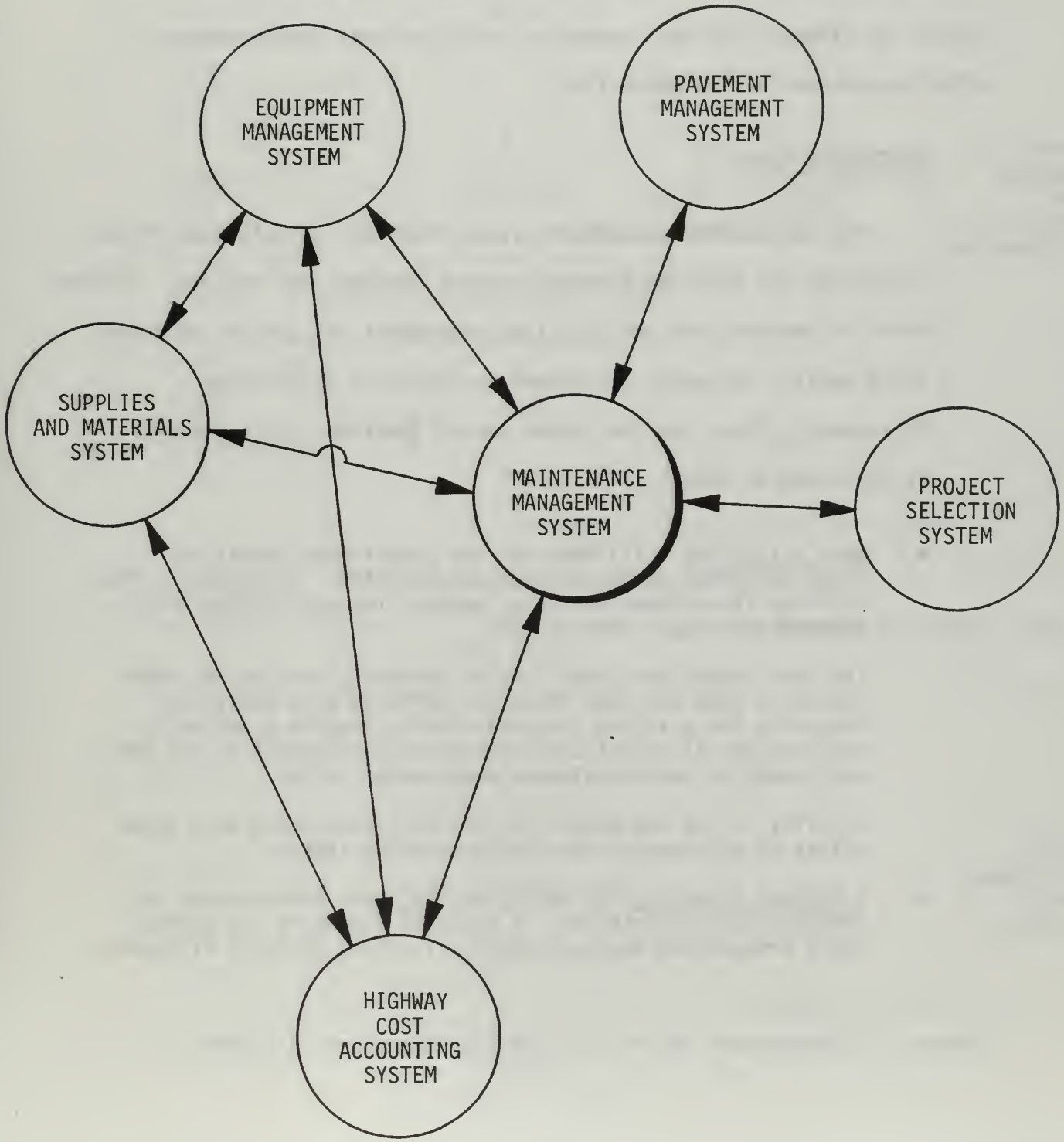
Interviews with Maintenance Division managers and operations personnel revealed a number of factors which must be considered in the system design. The most frequently expressed consideration is that the system be simple and easy to use by field-level management and administrative personnel. Other design considerations include the following:

- The system should encompass all maintenance and betterment activities performed by MDOH maintenance staffs, including road, bridge and traffic service-related functions.
- Management system improvements must be compatible with the systems used by accounting, equipment, project selection, supplies and materials, and pavement management. These relationships are illustrated in Exhibit 5.
- Performance (or program) budgets must be able to be readily reconciled with traditional line item budgets.
- Information for both planning and managing work must be timely and of suitable accuracy. Systems must be designed so that accounting data gathering efforts serve management needs. Also, the end-of-fiscal-year work slowdowns must be eliminated.
- Management system data processing needs should be designed to be compatible with existing MDOH data processing equipment. Annual, statewide work program and budget preparation should be performed on the State's IBM 370/158 main frame computers. Work management and control efforts at the field level should be served by the existing IBM Series I units currently serving each of the Division offices.

This "summary of findings" provides a general framework for considering the development of maintenance management system improvements. The maintenance management concepts described in Section III round-out the general system design requirements.

Exhibit 5

MANAGEMENT SYSTEM RELATIONSHIPS



III. RECOMMENDED MANAGEMENT SYSTEM AND ORGANIZATION PLAN

The findings and related needs, with regard to maintenance management improvements, establish the scope and character of the recommended maintenance management system. This section describes the recommended system, element by element, and then addresses organizational considerations affecting successful implementation.

1. CONCEPTUAL PLAN

The recommended management system provides logical, easy-to-use, procedures for developing effective work programs and budgets. Furthermore, it provides for the effective management and control of actual field works. The model diagrammed in Exhibit 6 illustrates, in schematic form, how the system should function. Each element is described in detail.

- Work activities - (1)[1] describe the significant operations being performed by the Maintenance Division. In addition, each activity is assigned a unit of measure for quantifying both planned and actual work results.

  The work number/work descriptions currently used by the MDOH provide a good starting point for defining work activities. Upgrading the existing list will simply involve a review to ensure that all significant operations are identified and the assignment of meaningful work measurement units.

  Activity review and update responsibilities should be a joint effort of maintenance and cost accounting staffs.

- A highway inventory (2) describes the types and quantity of features being maintained. A suitable inventory for maintenance programming purposes usually involves 20 to 30 different

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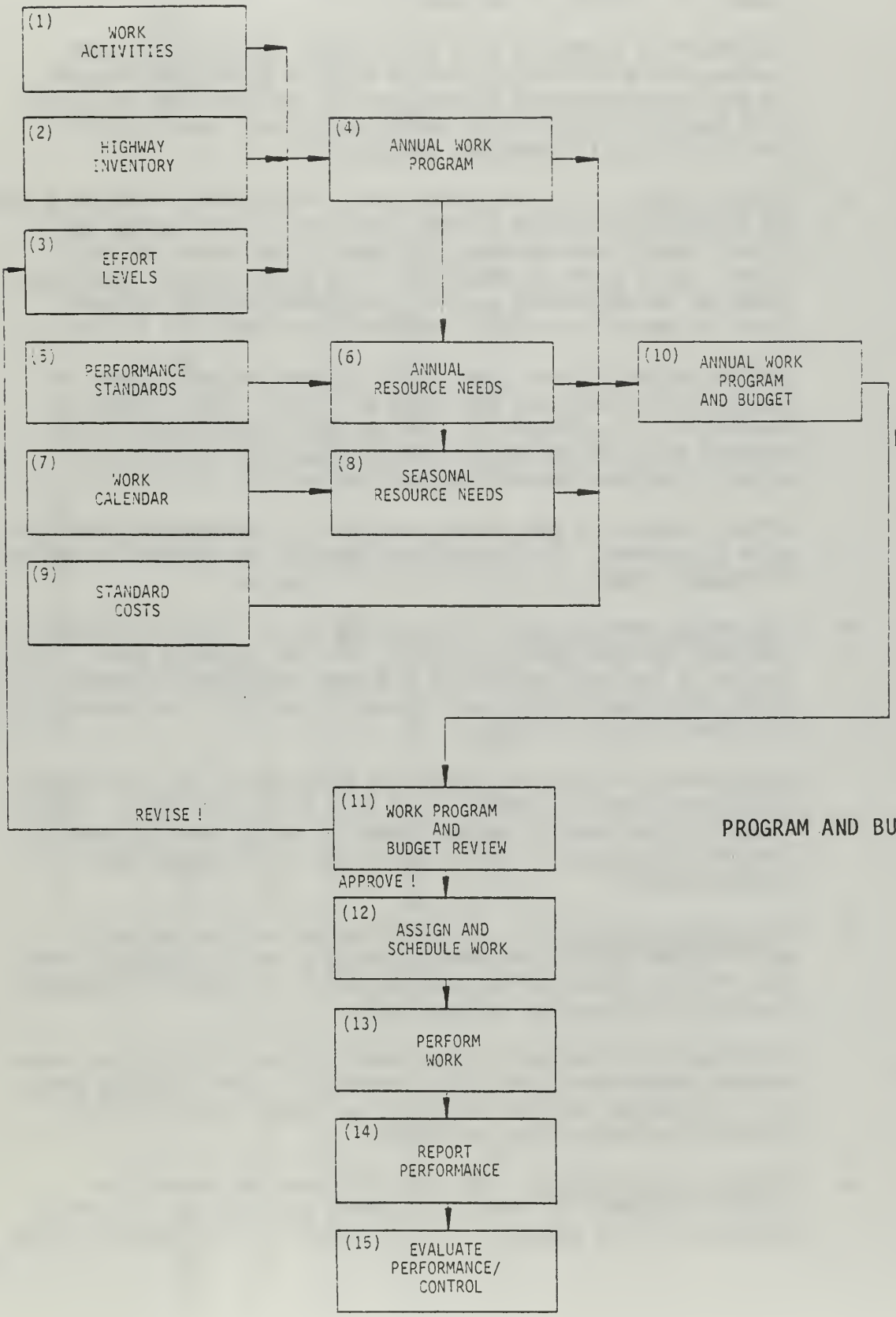
[1] Numbers in parentheses refer to system elements shown in Exhibit 6.

Exhibit 6

RECOMMENDED MAINTENANCE MANAGEMENT SYSTEM:
CONCEPTUAL DESIGN



features ranging from lane miles of concrete surface to number of roadside directional sighn.

Considerable inventory data is already available for road surface characteristics. Future efforts should concentrate on the inventorying of traffic service and drainage features. This data can typically be gathered by field forces after basic training in inventory procedures.

- Effort levels - (3) are established for each maintenance activity to estimate the amount of work required for the coming year. Effort levels are expressed in terms of the amount of work (tons, cubic yards, acres mowed, lane miles plowed, and so on) required to adequately service applicable roadway features (such as paved lane miles, mowable acres and miles of ditch).

  Setting effort levels needs to be a joint effort between the headquarters staff and the field divisions. Field input is essential -- to ensure that unique local conditions are considered while at the same time, headquarters is trying to attain a uniform state-wide level of service.

  Effort levels are the primary variable in determining how much work is planned. If planned work exceeds the budget's capacity to support them, the effort level is reduced.

- The annual work program - (4) describes for each maintenance activity how much work is planned for the upcoming year. Calculation of the work program is a simple arithmetic procedure, using the effort levels and highway inventory. The procedure is illustrated in Exhibit 7.

  Annual work programs are typically prepared to the maintenance supervisor-level of detail, (1/2 of a field division). Then, field division and statewide summaries can be easily prepared. Program preparation is performed by the maintenance headquarters staff.

- Performance standards - (5) describe for each maintenance activity the appropriate work method, as well as typical crew day resource needs and accomplishments. A typical performance standard is presented in Exhibit 8.

  Performance standards are developed for each activity by experienced headquarters and field personnel. Each standard should be reviewed and updated annually, as necessary, to reflect improved methods or new equipment.

- Annual resource needs - (6) are the types and amounts of labor, equipment and materials needed to carry out the annual maintenance work program. Actual resource needs determination,

Exhibit 7

TYPICAL ANNUAL WORK PROGRAM DETERMINATION

ACTIVITY	EFFORT LEVEL	X	HIGHWAY INVENTORY	=	ANNUAL WORK QUANTITY
Premix Patching	0.35 cy premix per bit. ln. mi.		1400 bit. ln. mi.		490 cy premix
Roadside Maxing	3 mowings per mowable acre		2,600 mowable acres		7800 acres mowed
Gravel Patching	25 cy gravel per non-paved mile		362 non-paved miles		9050 cy gravel
Crack Filling	10 gal. sealant per lane mile PCC		225 lane miles PCC		2250 gal sealant

PERFORMANCE STANDARD

ACTIVITY

410 ASPHALT POTHOLE PATCHING

DESCRIPTION

Eliminating potholes, localized severe depressions, breaks and other irregularities in asphaltic or concrete surfaces and paved shoulders by patching with either hot or cold asphaltic mix materials.

PERFORMANCE CRITERIA

Hazardous surface failures should be repaired immediately upon discovery whenever possible. Unless the condition presents a hazardous condition for motorists, surface and surrounding area should be dry before making the repair.

SCHEDULING AUTHORITY

Zone Foreman

TYPICAL DAILY CREW NEEDS

LABOR

1 truck driver
1 laborer
1 flag person (1/4 time)

EQUIPMENT

1 pickup with flashing light (1/4 time)
1 dump truck - 5 yd. (Patch King if possible)
1 vibrating plate compactor
Optional:
Propane heater for drying hole (1/4 time)

MATERIALS

Asphaltic hot mix 5-7 ton /8 hr. day
7-10 ton /10 hr. day
Optional:
Emulsion
Base Material

STANDARD WORK METHOD

1. Place signs and safety devices as required.
2. Remove all loose material and square area (vertical sides) to be patched.
3. Recompact base and sub-base materials when disturbed. Replace unsuitable base materials when necessary.
4. Apply a light, uniform tack coat for patches on high traffic volume roads.
5. Shovel hot mix into area to be patched. Material should be compacted in layers not exceeding 2 inches in thickness. Hand tamp edges as required.
6. Compact final lift so that patch is flush with surrounding pavement.
7. Sweep all loose material from surface.
8. Remove signs and safety devices.

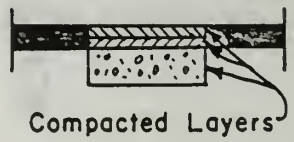
STANDARD ACCOMPLISHMENT AND RESULTS

5 to 7 ton of hot mix per 8 hour crew day -- 7 to 10 ton in a 10 hour day.

Initial Condition

Ready for Patch

Completed Patch



using both the annual work program and the performance standards is a two-step process: the first step being to determine the annual crew days of work; and the second being to identify specific resource needs. An example of these procedures is presented in Exhibit 9.

- The Work Calendar - (7) describes the seasonal characteristics of the maintenance program. Many activities can only be performed during certain months of the year. Others can be performed most any time. To translate the annual work program into a set of monthly or seasonal sub-programs, the work calendar indicates the percentage of each maintenance activity's work that can typically be performed each month. This sub-divided work program is a valuable aid to those responsible for developing short-term work schedules.

- Seasonal resource needs - (8) are identified by applying the monthly work quantity percentages from the work calendar to the annual resource needs determined in Element 6. This step is important for identifying the resources which are needed during certain seasons, (such as winter sand, snow plows, mowers, and pneumatic rollers).

- Standard costs - (9) for maintenance resources are used to determine the funds required to support the maintenance work program and budget. Typical standard costs include:

  + labor - established hourly rates plus allowances for employee benefits, and wage adjustments;

  + equipment - projected rental rates plus allowances for fleet replacment and minor capital outlay items; and

  + materials - projected unit costs for all significant maintenance materials.

- The Annual Work Program and Budget - (10) describes the annual work objectives for each activity (a reflection of service) and, on the same line, identifies the associated funding requirements. Exhibit 10 illustrates part of a typical annual work program and budget.

- Work Program and Budget Review - (11) is performed by top Department management, as well as the Legislature and Executive Branch. If the maintenance work program and budget is approved, the Maintenance Division is authorized to proceed with implementation. If the work program and budget is not approved, it is sent back to the Maintenance Division for revisions. Typical revisions will involve adjusting the effort levels, which result in modified service levels and funding requirements.

Exhibit 9

ONE APPROACH TO RESOURCE NEEDS DETERMINATION

FOR A TYPICAL MAINTENANCE ACTIVITY

Assume: Chip sealing operation in a typical division.

Annual work quantity = 60 lane miles

Average crew day accomplishment = 12 lane miles

Crew Days of Work = Annual work quantity Average crew-day accomplishment = 60 lane miles 12 lane miles/crew day = 5 crew days

Labor Requirements = Crew-days of work x standard crew size ... from

the Performance Standard: Standard Crew Size 4 Operators
6 Drivers
4 Laborers

Total Annual Labor-Days for Operators = 4 x 5 = 20 Labor Days
Total Annual Labor-Days for Drivers = 6 x 5 = 30 Labor Days
Total Annual Labor-Days for Laborers = 4 x 5 = 20 Labor Days

Labor-Days for sealing = 70 Labor Days

Equipment Requirements = Crew-Days of work x standard equipment use

... from the Performance Standard:
1 Asphalt Distributor per Day
6 Dump Trucks per Day
1 Roller per Day
1 Loader per Day
1 Tractor Broom per Day

Total Annual Days for Distributor, Roller, Loader and Broom = 5 Days Each

Total Annual Days for Dump Trucks = 30 Days (for the equivalent of trucks in five days)

Material Requirements = Crew-days of work x standard material requirements

... from Performance Standard: 19,000 Gallons of Liquid Asphalt per Day
634 Tons of Aggregate per Day

Annual Liquid asphalt Requirements for Sealing = 5 x 19,000 = 95,000 gallons

Annual Aggregate Requirements for Sealing = 5 x 634 = 3,170 tons

Exhibit 10

TYPICAL WORK PROGRAM AND BUDGET(PARTIAL)

ACTIVITY / ROAD INVENTORY		WORK PROGRAM					ANNUAL BUDGET				
CODE	DESCRIPTION / FEATURE MAINTAINED	ANNUAL WORK QTY	CREW-DAY ACCOMP	UNIT MEAS	CREW DAYS	LABOR DAYS	LABOR COST +	EQUIPMENT COST +	MATERIAL COST +	LUMP SUM COST =	TOTAL COST
422	DUST OILING										
	224 UNPAVED ROAD MILES	48,750	3,250	GAL	15	15	2,307	309	34,125		36,741
423	CLEARING AND GRUBBING										
	7 PROJECTS	17	.79	ACR	21	105	8,989	9,659			18,648
424	GRADING										
	7 PROJECTS	23,000	1,000	C-Y	23	184	21,231	34,638			55,869
425	BASE PLACEMENT										
	224 UNPAVED ROAD MILES	69,600	362.50	TON	192	1983	206,924	261,266	324,336		792,525
426	ASPHALT SURFACE SHOULDER PREPARATION										
	7 ZONES	9,205	110.90	TON	83	581	59,908	74,510	42,895		177,313
427	MISC SURFACE AND SHOULDER BETTERMENTS										
	1,457 ROAD MILES	700	70	L-H	10	70	7,448	7,005	3,500		17,953
429	OTHER SURFACE AND SHOULDER MAINTENANCE										
	1,457 ROAD MILES	1,770	45.38	L-H	39	195	19,205	19,104	3,900		42,209
430	CULVERT CLEANING										
	18,692 CULVERTS	4,328	16.15	NUM	268	557	50,605	17,965			68,570
431	CULVERT REPAIR										
	18,692 CULVERTS	142	2.15	NUM	66	165	14,000	6,064	1,980		22,044
432	CULVERT REPLACEMENT/INSTALLATION										
	1,457 ROAD MILES	3,161	81.05	L-F	39	156	16,145	17,890	49,437		83,472
434	DITCH MAINTENANCE - GRADER										
	1,753 DITCH MILES	60	2.50	D-M	24	144	16,337	23,580			39,917
435	DITCH MAINTENANCE - GRADALL										
	1,753 DITCH MILES	187	.48	D-M	389	1362	136,532	186,385			322,917
436	STORM SEWER CLEANING										
	159,738 FEET OF STORM SEWER	52,000	852.46	L-F	61	244	20,190	27,604			47,794
437	CATCH BASIN CLEANING										
	1,381 CATCH BASINS	940	42.73	NUM	22	66	5,803	6,819			12,622
438	DRAINAGE FACILITY BETTERMENT										
	1,457 ROAD MILES	630	45	L-H	14	70	6,861	7,011	2,450		16,322

- Assignment and scheduling of work - (12) can begin once the work program and budget have been approved. Approved programs serve as authority to the field divisions to proceed. Short-term schedules are prepared at the field level to ensure realization of work program goals, while at the same time continuing to respond to emergency and special maintenance needs. A typical two-week schedule for field level operations is shown in Exhibit 11.

- Performing work - (13) is the most important aspect of the entire system. Without actual performance, a system is not required.

- Reporting work performance - (14) at the field level is necessary to ensure that both management and accounting data are timely and accurate. Specific data requirements include labor hours, equipment and material use, and work accomplishment. Aside from work accomplishment data, all other data is now being reported.

- Evaluating work performance and exercising work control - (15) are primary responsibilities of maintenance managers intent on meeting planned work objectives with budgeted resources. To support these needs, the management system will provide periodic feedback reports that compare planned and actual performance. A typical report, suitable for performance evaluation, is shown in Exhibit 12.

2. ORGANIZATIONAL CONSIDERATIONS

The recommended maintenance management system is designed to operate with the Department's existing management structure -- or within a modified structure.

Effective management systems for maintenance have been implemented in a wide variety of organizational structures -- from highly centralized agencies to large decentralized organizations.

- Centralized Organization and Maintenance Management

  Systems in operation in centralized organizations tend to be characterized by:

  + relatively short lines (or channels) of communication;

Exhibit 11

TYPICAL FIELD MAINTENANCE SCHEDULE

TWO-WEEK SCHEDULE

Period From Sept. 15, 1981 To Sept. 30, 1981
Crew Leader Rice Planning Unit 130
Approved By Ralph Pittyard

ACTIVITY CODE	ACTIVITY DESCRIPTION	LOCATION	Planned Period Accomp.	Crew Days ⊗	Crew Size ⊜	Planned Labor Days	LABOR DAY ASSIGNMENT NEEDS Mon.16	Tues.17	Wed.18	Thurs.19	Fri 20	Mon.23	Tues.24	Wed.25	Thurs.26	Fri 27
435	Ditching Gradall	River Rd.	25mi.	5	4	20	4	4	4	4		4				
418	Shoulder Bldg.	Hileman Ln.	48Sh.mi.	5	2	10	2	2	2	2		2				
419	Shoulder Restr.	Sovern Ln	400ton	3	6	18							6	6	6	
020	Supervision	Zonewide	80hr.	8	1	8	1	1	1	1		1	1	1	1	
492	Bldg. & Ground	Shop	20hr.	2	1	2								1	1	
	Alternate Work															
430	Culvert Clean	As Required														
431	Culvert Repair	As Required														
444	Emergency	As Required														
	ALL LEAVE -					6	1	1	1	1		1	1			
	TOTAL PLANNED LABOR-DAYS					64	8	8	8	8		8	8	8	8	

No. of Persons ⊗	Working Days ⊜	Available Labor-Days
8	8	64

COMMENTS

Gradall available for overhaul after Sept. 24

DISTRIBUTION

Original: Crew Leader
Copy: Supervisor

CREW EQUIPMENT	ACTIVITY EQUIPMENT NEEDS Mon.	Tues.	Wed.	Thurs.	Fri.	Mon.	Tues.	Wed.	Thurs.	Fri.
Gradall	435	435	435	435		435				
10 Ton Truck	435	435	435	435		435	419	419	419	
10 Ton Truck	435	435	435	435		435	419	419	419	
Grader	418	418	418	418		418	419	419	419	
Pickup	020	020	020	020		020	020	020	020	
Crew Cab	435	435	435	435		435	419	419	419	

Note

This schedule reflects a level o detail that may not be appropriate in Montana.

Exhibit 12
TYPICAL WORK CONTROL REPORT

RUN 9/25/80 FISCAL YEAR 1980 WORK CONTROL REPORT PAGE 009

PLANNING UNIT 130 ZONE 3 FOREMAN ORVILLE RICE ACTUAL VS PLANNED YEAR TO DATE FROM 07/01/80 THRU 09/30/80

********** A C T I V I T Y **********		** ACCOMPLISHMENT *			**** LABOR DAYS ***			***** EXPENDITURE *****			**** UNIT COST ****		
CODE DESCRIPTION	U/M	ACTUAL	PLANNED	A/P%	ACTUAL	PLANNED	A/P%	ACTUAL	PLANNED	A/P%	ACTUAL	PLANNED	A/P%
410 ASPHALT POTHOLE PATCHING	TON	7	9	78	2.2	2.0	110	$445	$520	86	$63.57	$57.77	110
416 GRAVEL ROAD BLADING	R-M	28	51	55	10.0	21.0	48	$3,487	$6,693	52	$124.54	$131.24	95
418 SHOULDER BLADING	S-M	58	51	114	19.5	16.0	122	$5,332	$4,017	132	$91.41	$78.76	116
419 SHOULDER RESTORATION	TON	175	282	62	7.2	13.0	55	$2,645	$4,560	58	$15.11	$16.17	93
420 STREET SWEEPING	L-M	72	87	83	3.5	5.0	70	$1,075	$1,485	73	$14.93	$17.07	87
423 CLEARING AND GRUBING	ACR	1.2	0		1.0	0		$1,150.	0		$958.33	0	
424 GRADING	C-Y	1,750	1,800	97	16.3	14.0	116	$5,004	$4,371	114	$2.86	$2.43	118
425 BASE PLACEMENT	TON	1,956	2,321	84	48.7	56.0	87	$23,780	$25,559	93	$12.15	$11.01	110
426 ASPHALT SURFACE SHOULDER PREP.	TON	185	325	57	10.0	18.0	56	$3,990	$6,139	65	$21.57	$18.89	114
427 MISC SURFACE AND SHOULDER BETTER	L-H	10	30	33	1.0	3.0	33	$198	$753	26	$19.80	$25.10	79
429 OTHER SURFACE AND SHOULDER MAIN.	L-H	25	40	63	2.5	4.0	63	$712	$943	76	$28.48	$21.93	130
430 CULVERT CLEANING	NUM	76	80	95	4.2	6.0	70	$985	$1,270	75	$12.96	$15.83	82
431 CULVERT REPAIR	NUM	0	0		0	00		0	0		0	0	
432 CULVERT REPLACEMENT/INSTALLATION	L-F	426	256	166	18.0	12.0	150	$9,125	$6,723	136	$21.42	$26.26	82
434 DITCH MAINTENANCE-GRADER	D-M	11	7	157	13.5	17.0	79	$3,720	$4,658	80	$338.18	$665.43	51
435 DITCH MAINTENANCE-GRADER	D-M	2.3	6	38	22.8	41.0	56	$5,835	$11,091	53	$2536.96	1858.50	137
438 DRAINAGE FACILITY BETTERMENT	L-H	442	20	210	4.2	2.0	210	$1,053	$572	185	$25.19	$24.87	101
439 OTHER DRAINAGE MAINTENANCE	L-H	70	70	100	7.0	7.0	100	$1,521	$1,769	86	$21.73	$34.02	64
TOTAL:					200.6	256.5	78	$71,368	$82,562	86			

+ fairly simple operating policies and procedures;

+ generally uniform patterns of decisions regarding work methods and service levels among subordinate units; and

+ relatively close contact with subordinate unit managers and supervisors.

The Maintenance Division currently shares these characteristics, (except for uniformity in patterns of decisions). Existing lines of communication are short, operating policies and procedures are straightforward and the Division headquarters staff keeps in close touch with Field Division staffs -- all representing a real "plus," from a maintenance management point of view.

Most maintenance managers who function within a centralized organization also recognize the need for special efforts to keep in touch with local problems and concerns. This need is generally met through middle-level managers who face the public, almost on a daily basis.

- Decentralized Organization and Maintenance Management

Systems in operation in decentralized organizations tend to be somewhat more sophisticated than those in centralized agencies. There are four reasons: (1) the lines of communication are usually longer, (2) operating policies and procedures are usually more detailed, (3) greater efforts are needed to ensure uniform patterns of decisions regarding work methods and service levels, and (4) decentralized organizations tend to be larger -- a factor that, in itself, demands greater sophistication.

Headquarters maintenance staffs in decentralized, state-level organizations must rely on effective management systems, to plan, budget and control maintenance. (In fact, most state-level systems were designed for decentralized organizations in which top management and staff maintenance managers wanted to "get a better handle" on field operations.)

Any system developed in Montana must take into account these organizational factors.

IV. ANALYSIS OF ALTERNATIVES

Three basic alternatives are analyzed in this section:

One: Develop and implement a maintenance management system that is fully consistent with the conceptual design (summarized in Section III). The main options related to this alternative are:

- System Development: In-house versus consultant assistance;
- Project Scope: Maintenance system alone versus a combined maintenance and equipment management project;
- Maintenance Program Focus: Centralized versus decentralized;
- Computer Software Development: Develop in-house or use other agencies' programs; and
- Computer Software Support - Field level: On-line versus batch mode.

Two: Develop and implement a modified system -- one that functions independently from the Department's accounting system.

Three: Supplement the existing headquarters maintenance staff -- to increase the Division's capability to analyze maintenance data. Hire a management analyst.

1. DEVELOP AND IMPLEMENT A MAINTENANCE MANAGEMENT SYSTEM

This alternative provides for developing and implementing a maintenance management system, as described in the conceptual design (in Section III). The overall design meets all of the requirements developed during the course of the study, by top management and by the User Steering Committee:

- The system will provide improved procedures for planning, budgeting and scheduling work;

- The methods used for monitoring and controlling performance and costs will be effective and timely; and

- User procedures will be straightforward and easy to apply.

The costs and benefits associated with this alternative are relatively high. As detailed in Section V, the total cost of developing and implementing the new system would be about $466,450, including consultant costs of $170,000. Annual cost savings associated with this alternative are estimated to be about $2 million.

The main options related to this alternative are as follows:

- System Development: In-House Versus Consultant

  Maintenance management systems are currently operating in almost 40 states -- nearly all of which are willing to provide manuals, reports and computer programs to the Department for use in developing a system. The system logic is relatively straightforward and easy to comprehend. Given enough time, a system could be developed and implemented with in-house staff. Experience shows that systems developed and implemented in-house typically require two to three times as long as those using full-time consultant assistance. Systems developed and implemented without consultant assistance also require significant, temporary staffing adjustments.

  Several experienced consulting firms are qualified to assist the Department in developing and implementing a maintenance management system. Aside from their direct cost, they offer three unique advantages:

  + Timely completion of system development and project implementation, as they can be held to contracted completion dates;

  + Improved system designs due to previous "hands on" experience with other agencies; and

  + Minimal disruption to existing operations, as no major personnel adjustments are necessary to undertake the project.

These trade-offs must be considered and costed before the Department elects to employ a consultant or to use only in-house staff. As a general rule, consultant-supported projects require one person, full-time, to serve as project coordinator (or director). The same person usually spends half-time to full-time on system-related work following the project. Projects conducted without consultant support usually require one or two people, to assist the project coordinator. Following a project, the assistants are usually transferred to other positions. (There are exceptions. The Florida DOT, for example, maintains a staff of three to four people to operate a system developed several years ago.)

- Project Scope: Maintenance Project Versus Maintenance/ Equipment Project

  An effective maintenance management system will indicate the specific types and amounts of equipment required by the Maintenance Division. This equipment need constitutes approximately 80 percent of the Department fleet.

  Given the close relationship between maintenance and equipment functions, it is essential that their respective management systems be compatible. If equipment management responsibilities are assigned to the Maintenance Division (through restructuring of the organization), the development of a completely integrated system is a logical course of action. Also, the total costs of systems development may be less than if pursued separately.

  If, on the other hand, maintenance and equipment management responsibilities are not combined and/or resources are not available to pursue both projects concurrently, suitable systems can be developed separately.

- Maintenance Program Focus: Centralized Versus Decentralized

  Maintenance work programs and budgets need to reflect and be responsive to service needs. Furthermore, resulting service levels should be uniform throughout the entire state.

  Centralized program development would be performed primarily by the Maintenance Division's headquarters staff. Of course, such an effort would require considerable inputs from the field divisions in establishing area-sensitive effort levels, performance standards and work calendars.

Decentralized program development would be performed by Division (or District) Staffs. Such programs may well reflect a more detailed appreciation of local problems and maintenance needs. However, this approach would require considerable review and program adjustment at Maintenance Division headquarters, to ensure that all of the separate programs reflected a uniform level of service.

- Computer Software Development: In-house Development Versus Adaptation of Existing Programs

Computer software packages for maintenance management systems are readily available from many state agencies. Several of these systems can be adapted for use on MDOH facilities, at least for work program and budget development. Potential savings from this strategy may run from $20,000 to $30,000 in in-house systems development labor and computer-time costs.

Computer programs developed in-house have the advantage of serving specific system needs. In-house programs preclude the potential problem of having to sacrifice desired system elements (or use unneeded ones), just to save on software development costs. Furthermore, in-house systems have the advantage of better maintenance and easier modification, so long as the in-house staff has full knowledge of the entire set of programs.

- Computer Software Support - Field Level: On-Line Batch Mode

Field divisions need timely information on costs, resource use and accomplishments -- to manage effectively.

Existing computer facilities in the field currently process management information in batch mode. These same facilities could be adapted to handle the full spectrum of maintenance management reports, with a probable turn-around time of no more than two weeks after the entry of field data.

On-line, current status reports are technically possible, if deemed necessary. Such an option would require modifications/upgrading of existing field computer hardware. Of course, even these reports would have time lags due to the periodic entry of field data. Also, program and budget preparation usually requires the type of computer support provided by centralized computer services. Adapting the existing Field Division computer facilities for this purpose may require more complicated computer applications than would centralized processing.

2. DEVELOP AND IMPLEMENT A MODIFIED SYSTEM

The project staff also considered development and implementation of a system that would function independently -- one that would "stand alone," without an interface with the Department's accounting system, or SBAS.

A number of maintenance management systems lack an accounting interface. As a general rule, standard daily (or unit) costs are used to develop a maintenance performance budget and to provide a rough accounting of the funds spent. (Standard costs are typically used as an approximation of actual expenditures.) This approach clearly has one advantage: it typically includes all of the system elements outlined in Section III, except for the actual cost feature. This modified system operates without the work needed to ensure accurate accounting of costs. Also, system development and implementation costs are usually lower. But there are real disadvantages:

- The standard costs (from the system) and the actual costs (from accounting data) rarely match. This problem, alone, is in several agencies, resulting in serious credibility gaps. As a result, some agencies are now overhauling their modified system, to reflect actual expenditures.
- As we understand it, a credibility gap already exists in Montana because SBAS and Department cost data does not match. A "stand alone" maintenance management system using standard costs to approximate actual costs would simply widen the gap.
- A modified system would not resolve the problems associated with a lack of time and accurate cost information, as identified by the User Steering Committee.

A further refinement of this alternative -- eliminating cost data in total -- was not considered because it fails to meet User Committee requirements, as well as those defined by top management.

The estimated total cost associated with a modified system is $426,450 -- $40,000 less than a fully integrated system. Department costs would be about $15,000 less as a result of reduced data processing and field training expenses; consultant fees would be about $25,000 less because system development and implementation time could be reduced by about 55 man-days.

System benefits would be comparable to those outlined in the first alternative, except for a continued lack of timely cost data -- a factor that is resulting in wasted time and costs in May and June each year, (as noted on page 14).

3. RETAIN MANAGEMENT ANALYST CAPABILITIES

The existing headquarters maintenance staff might be supplemented by a trained management analyst -- to collect, analyze and summarize maintenance operating data. The analyst would function in essentially the same way a consultant would, in reviewing day-to-day operations. In fact, this person could continue the research represented in this report.

This alternative has three advantages: (1) the analyst could assemble facts to further support the need for improved management practices, (2) administrative staffs and committees could be asembled to make spot improvements based on the analyst's recommendations and

(3) the costs associated with the spot improvements would be less than system development and implementation.

The disadvantages associated with employing a trained management analyst are as follows:

- There are no assurances that an analyst could function properly. In fact, the experiences of several state highway departments clearly indicate that an analyst becomes involved in day-to-day operations, to the extent that very little analytical work gets done.
- A trained management analyst receives an annual salary of about $30,000 -- far beyond the compensation that is within existing Department salary structures (for comparable positions).
- It is very unlikely that a management analyst could develop and implement an effective maintenance management system.

The costs associated with this alternative, including salaries and benefits of the analyst, headquarters staff report and committee expenses would be about $85,000 per year. Implementation of improvements recommended by the analyst would represent an additional cost.

The benefits associated with this alternative depend, of course, on a variety of factors -- from the work assigned to the analyst to the extent to which the data collected by the analyst results in improved management practices. Actual improvements might be expected to result in a cost savings of as much as $150,000 per year for two years. Following that, it is likely that the analyst would become involved in day-to-day operations, and that there would be no further benefit.

4. COMBINED MAINTENANCE AND EQUIPMENT PROJECTS

The project staff also evaluated the possibility of conducting a combined road maintenance management-equipment management project. A combined project may have several advantages, including (1) fully compatible and consistent definitions of terms and practices, such as reporting "equipment availability" and "utilization," (2) common understandings of the need for adequate equipment classifications and rental rates, (3) reduced development and implementation costs -- with or without consultant assistance. The only potential disadvantage is that the Department may not have available all of the data processing support needed to implement both systems at the same time.

V. RECOMMENDED COURSE OF ACTION

The recommended course of action for the Department is to develop and implement an effective maintenance management system. The system must include:

- Improved procedures for planning and scheduling work;
- Effective and timely methods for monitoring and controlling performance; and
- User procedures that are straightforward and easy to apply.

Furthermore, the benefits from the system must outweigh the costs of development and implementation.

This section describes the basic steps involved in a project to develop an effective maintenance management system. It also outlines system development costs and benefits.

1. PROPOSED PROJECT PLAN

The proposed project plan involves two distinct stages:

- Stage 1 -- Research and development of the new management system; and
- Stage 2 -- System implementation.

It is expected that the entire project (with consultant assistance) will require 20 calendar months -- 10 to 12 months for Stage 1, and 8 to 10 months for Stage 2.

Prior to inception, it is recommended that two committees be established to monitor the project. They are:

- An Advisory Committee - This committee should consist of six senior Department executives who will provide overall guidance and direction to the project. Committee meetings should probably be held every three months, to review project progress, accomplishments, problems and solutions.

- A Steering Committee - This committee should consist of nine managers and field personnel from the Maintenance and Equipment Divisions. They should meet every two months to review the technical aspects of the project.

Specific project steps are described below:

STAGE I - SYSTEM RESEARCH AND DEVELOPMENT

- Review Organization and Management Practices Report - At the beginning of the project, the project staff should review with the Advisory Committee the "Organization and Management Practices Report," (this report). Any modifications or changes in report contents that will affect the course of the project should be made.

- Prepare Project Policy Statements - Specific project policies should be drafted, which relate to the application of system concepts, to include:

  + Service levels and related effort levels -- a definition of the Department service goals;

  + Performance standards -- a recognition of what aspects of work will be standardized; and

  + Field management procedures -- determining which factors of performance will be used to monitor work, and at which management levels.

  These Policy Statements need to be reviewed and finalized with the Advisory Committee.

- Conduct General Orientation - A project orientation should be conducted for all Maintenance Division supervisors. During the orientation, project objectives should be described, as well as the work to be done and results expected.

- Provide Maintenance Management Training - The orientation should be followed by periodic, formal training in maintenance management concepts. The training, designed mainly for field supervisors, should cover a broad range of topics -- from "setting maintenance objectives" and "measuring performance" to "effective work control."

  All training conducted during the project should be coordinated with the Department Training Officer.

- Refine Work Activities - Refinements should be made in the way work is defined and measured, and functional categories of work should be established, based on the extent to which each activity can be planned and controlled. During this step, the project team should provide guidance in making all the refinements needed to establish useful definitions, work measurements and functional classifications.

  Existing definitions, now used for cost accounting purposes, should serve as starting point for describing and measuring work. The new definitions must provide both management and cost accounting data.

- Revise/Implement Work Reporting - The modified work activity definitions and measurement units should be utilized in a revised work reporting procedure. This procedure should provide for recording and summarizing the amount of work performed and the number of labor hours spent on the work -- activity by activity. During this step, formal training should be conducted for everyone involved in the work reporting process.

- Develop Performance Standards - Extensive discussions with Department supervisors, informal field observations and data from other agencies should be used to develop draft performance standards for most of the work activities. The standards should outline the optimum crew size, equipment, materials and work methods -- on an activity-by-activity basis.

  The standards must define specific improvements in current practices, expecially for activities that require significant amounts of labor and equipment. But there should be no "short-cuts." Each standard needs to reflect acceptable methods and Department policies. The standards also must take into account the fact that weather conditions and haul

distances vary considerably from one part of the state to another.

- Conduct Highway Inventory - Highway features requiring maintenance should be identified, as they apply to each maintenance activity. Then, an actual inventory of the network's features should be made, using existing data (when available) and by conducting visual, on-site inspections (counts) of those features for which no records exist.

- Conduct Work Load and Practices Review - An analysis of historical data and field interviews should be used to establish indications of current work loads and practices. Data also needs to be collected relative to employee leave patterns and past expenditure patterns. (This analysis should not be sophisticated, but instead provide only the data needed for work program development.)

- Develop Annual Work Programs and Budgets - Estimates must be made of the kinds and amounts of maintenance that need to be done, to achieve Department goals. During this step, the project team needs to work closely with the Maintenance Division Administrator and his staff, to:

  + Identify the levels of service being provided by each activity or combinations of activities;

  + Identify the need for increases or decreases in specific service levels; and

  + Develop several draft maintenance programs.

  Refinements also must be made in the procedures used to develop maintenance budgets. The new procedures should reflect reasonable estimates of the dollars required to implement each maintenance program alternative.

  Note: The performance or program budgets must be reconciled with existing line-item budgets.

- Identify Resource Requirements - Estimates must be made of the number of people, the types and numbers of equipment units and the quantities of materials required to carry out selected maintenance programs. The estimates should be based on planned quantities of work, the performance standards and on individual projects being developed by the Department.

- Calculate Work Load Distribution - The maintenance work load, as established in the annual programs, needs to be distributed throughout the months of the year, making maximum use of activities having some scheduling flexibility -- to level the work load and reduce peak demands for resources. This leveled work load should be converted to work calendars which show the months in which work in the annual programs should be performed.

- Refine Work Scheduling and Control Procedures - Refinements need to be made in the procedures being used to schedule and control maintenance.

  Scheduling and work control techniques proven effective in other maintenance agencies should be evaluated in view of current scheduling procedures, and modifications of these techniques should be desinged for use by maintenance supervisors. The techniques developed for the Maintenance Division should, at a minimum, take advantage of the service levels, work calendars and unique operating conditions throughout Montana.

- Design Management Information System: Data Processing - The improvements made in maintenance planning, budgeting and work reporting should be supported by electronic data processing. To satisfy this need, the project team must allocate whatever time is required to complete three major tasks:

  + Work with the Maintenance Division Administrator and his staff to identify the needs for management and cost information;

  + Collect, from several public works agencies (if requested), the (EDP) program descriptions and report formats that best meet the Department's needs; and

  + Work with the Central Services Division to make the programs operational on state equipment.

  Information system design needs to commence early in Stage I and be completed prior to the 10th month of the project.

STAGE 2 - SYSTEM IMPLEMENTATION

- Prepare Management Manuals and Training - Results of project efforts to improve work methods and management practices should be shaped into at least two manuals -- a field management manual that serves as a reference to the new procedures and performance standards, and a "systems" manual designed for use by the Administrator and his staff.

  Most of the training should be conducted on an individual or small-group basis -- to provide the personal attention needed to improve upon current practices.

- Implement Work Programs and Budgets - The draft work programs will present an excellent opportunity to make real improvements in the way top management approves Maintenance Division plans and in the way the plans are communicated to field managers.

  During this step, the project team should assist the Maintenance Division Administrator and his staff in:

  + refining the work programs;

  + preparing budgets, based on the work programs;

  + presenting the work programs and budgets to the Department director; and

  + implementing the approved programs.

  The "performance" budget, itself, must be reconciled with the traditional, line-item budget.

- Implement Field Management Procedures - The performance standards, together with improved scheduling procedures, must be implemented. The scheduling procedures will provide for planning work in accordance with the work programs. But the flexibility needed to respond to absenteeism, equipment breakdowns and emergencies should be incorporated in the new procedures.

Work accomplishment and resource usage should continue to be reported. The data should be processed monthly and/or quarterly, to provide summaries of actual results compared with that planned. In addition to the day-by-day evaluation and control by supervisors, the Maintenance Division must also have the information needed to take corrective actions, and to modify schedules.

- Update and Review - Essentially all of the work performed to prepare the initial performance standards, work program objectives and budgets needs to be repeated, during the final months of the project:

  + The inventory will need to be updated to reflect any changes that have occurred since the initial update;

  + Performance standards and other elements should be reviewed and revised, as appropriate; and

  + "Second-year" programs and budgets should be prepared.

  This step should be timed to coincide with the State's work programming budgeting processes for FY 1984-85.

- Initiate Spot Improvements - Throughout most of Stage 2, performance needs to be evaluated, and corrective actions should be highlighted in informal reports to Division managers. Specific attention should be given to defining and implementing spot improvements in maintenance work methods and administrative practices.

- Initiate System Improvements - Research findings from other agencies should be made available to Department managers. Potential improvements in system procedures, personnel training, data processing and related areas should be reviewed with the staff.

OTHER WORK

- Submit Project Reports - Two kinds of formal reports should be prepared, in addition to those described above:

  + A monthly progress report should be prepared every month of the project -- to describe the work being done, in terms of the work plan and schedule; and

  + A final report should be prepared to document project accomplishments and results. This brief report should be written in ways which can be readily understood by persons who do not have a technical orientation and background.

2. DEVELOPMENT AND IMPLEMENTATION COSTS

The amount of effort it takes to develop and implement a new maintenance management system has varied widely from one state to another. But as a general guide, it is estimated that about 2,360 man-days will need to be allocated to the work, over a period of 20 months. Exhibit 13 provides a breakdown of the man-day requirements. Nearly all "headquarters," "data processing" and "consultant" time represent direct efforts. "Field" time is largely allocated to participation in system training sessions.

Given the man-days detailed in Exhibit 13, the total cost would be somewhere around $466,000, including about $175,000 in consultant assistance. It should be emphasized that the time and cost estimates are preliminary. They are based only on a tentative project scope and objectives, and on cost experiences of other state-level maintenance management projects. A breakdown of the estimated cost is provided in Exhibit 14. (Consultant costs generally range from $65,000 for part-time assistance and greater agency support, to $250,0000 for full-time assistance, including technical guidance in management training, accounting and data processing.)

The on-going costs of operating and maintaining the new system are easily defined. One person, at least half-time, and data processing support, costing about $45,000 per year, will be required following system implementation. All other costs (such as the time-cost for

Exhibit 13

PRELIMINARY MAN-DAY ESTIMATE
FOR A 20-MONTH PROJECT TO DEVELOP AND IMPLEMENT
A NEW MAINTENANCE MANAGEMENT SYTEM

Individual or Group	Estimated Man Days
Administrator, Maintenance Division	20
Project Coordinator/Director	400
Other Headquarters Maintenance Personnel (typing, clerical and other)	180
Data Processing staff (2 people)	250 [1]
Field Bureau Chiefs (11 people)	110
Maintenance Supervisors and Foremen (157 people)	790
Other Field Support (including administrative division staffs)	110
Advisory Committee (5 people/6 meetings)	30
Steering Committee (9 people/10 meetings)	90
Consultant Assistance	380
Total Estimated Man Days	2,360

[1] Assumes development of programs for 8 to 10 reports.

Exhibit 14

PRELIMINARY COST ESTIMATE
FOR A 20-MONTH PROJECT TO DEVELOP AND IMPLEMENT
A NEW MAINTENANCE MANAGEMENT SYSTEM

Individual or Group	Approximate Total Cost
Administrator, Maintenance Division	$ 3,000
Project Coordinator/Director	45,680
Other Headquarters Maintenance Personnel	17,380
Data Processing Staff	38,750
Field Division Chiefs	30,250
Maintenance Supervisors and Foremen	62,800
Other Field Support	9,900
Advisory Committee	5,160
Steering Committee	10,000
Total Direct Salaries	$222,920
Fringe Benefits	46,810
Total Personnel costs	$269,730
Estimated Expenses	
Travel and Subsistence 250 days @ $38	$ 9,120
Vehicle Rentals 360 days @ $35	12,600
Consultant Fees	175,000
Total Expenses	$196,720
Total Estimated Project Cost	$466,450

using the new scheduling procedures) are absorbed in the normal course of managing maintenance work.

3. SAVINGS AND BENEFITS

As with project efforts and costs in other agencies, actual project benefits vary considerably, depending on such factors as the extent of top management commitment, the level of system training provided and the overall approach taken by the project staff. (For example, a system that is implemented without considerable field-level involvement and training tends to produce fewer benefits than one in which involvement and training are relatively high.) But the potential benefits in Montana are significant:

- Improved planning and budgeting - The performance (or program) budgeting approach common to maintenance management systems establishes specific relationships between effort levels (or service levels) and dollars. This approach establishes budgets that are based on planned performance, activity by activity. In effect, the budget for each field division can be based on the amount of work each division plans to accomplish. A performance budget also documents planned uses of funds -- a measure that encourages legislative support.

- Uniform levels of service - The levels of service being provided can be standardized, from one field division to another. Maintenance management procedures developed during the project will encourage consistent decisions regarding how much maintenance needs to be done.

- Improved resource allocation - Performance budgeting techniques also can provide the information needed to allocate resources and funds on the basis of maintenance needs. As in most maintenance management systems, Department managers will be able to determine the number of people and the number and types of equipment required to support the maintenance program in each field division.

- Improved work load distribution - Special techniques can be used to help Department managers cope with the peaks and valleys normally associated with maintenance work loads. In effect, maintenance calendars can be developed to help level-off the peaks and fill in the valleys in work loads.

- Increased productivity - Performance standards and field scheduling procedures implemented in many state-level agencies have brought about productivity increases ranging from 5 to 20 percent. These productivity increases generally have resulted in cost savings of around 7 percent of the total maintenance budget.

- Improved workmanship - The performance standars and scheduling procedures also encourage better workmanship. The standards, for example, increase a supervisor's awareness of what is expected, in terms of maintenance work methods and results. (Additional improvements in work methods can be achieved through appropriate technical training.)

- Better management information - Refinements can be made in current reporting procedures, to provide timely information regarding work accomplishments, performance and cost, by maintenance activity and by object of expenditure. Both management and cost accounting data can be collected on a daily basis, in ways that ensure accurate information -- information that will improve the decision-making process at all levels of management.

- Improved contract management capability - In addition to the unit cost data provided by a new system, techniques can be developed to (1) help determine what activities should be let to contract, (2) structure contracts in ways that promote good performance and (3) provide the tools needed to manage contracts effectively. The same techniques also can be used to evaluate the relative impacts associated with performing city street maintenance.

- Reduced budget preparation costs - About 27 man-months are now being allocated each year to developing annual maintenance budgets. System budgeting procedures will cut that time by at least 50 percent, and will save an estimated $50,000 in labor and employee benefit costs, and expenses.

It appears that the 7 percent annual savings typically realized from productivity improvements is a very reasonable "best estimate" for Montana. Evidence to support this lies in the significant inefficiencies presently

experienced by the Maintenance Division, at fiscal year end. In discussions with several Field Bureau Chiefs, it was discovered that crews worked at approximately 50 percent of the effective capability due to inadequate pavement-related materials during the months of May and June. This, of course, results from the already mentioned need for improved timeliness in cost control data -- a problem that the management system must eliminate.

The cost of the "50 percent effective capability" can be translated into about 7 percent of the annual maintenance budget -- or nearly $2,000,000.

Evidence provided by a number of state highway maintenance agencies suggests that even ignoring the "50 percent effective capability" in Montana, productivity improvements result in real cost savings -- savings that are used to increase levels of maintenance service and/or expand preventive maintenance or betterment programs. Comparable savings -- somewhere around $2,000,000 -- and comparable benefits -- more maintenance for the dollar -- can be expected in Montana.

The cost savings associated with a maintenance management system begin soon after implementation, and continue as long as managers use the system to manage maintenance. Over a five-year period, the savings can be expected to add up to about $10 million -- over 20 times the cost of developing and implementing the system.

R.J. HANSEN ASSOCIATES, INC.

MANAGEMENT AND INFORMATION SYSTEMS CONSULTANTS

EQUIPMENT

MANAGEMENT INFORMATION NEEDS ANALYSIS

FOR THE

DEPARTMENT OF HIGHWAY
STATE OF MONTANA

July 1981

FINAL REPORT

ON ORGANIZATIONAL AND MANAGEMENT PRACTICES

EQUIPMENT

STATE OF MONTANA

DEPARTMENT OF HIGHWAYS

Prepared by:

R. J. Hansen Associates, Inc.

July 29, 1981

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I. INTRODUCTION

A study was conducted by Burke & Associates, Inc., in association with R. J. Hansen Associates, to determine the improvements needed in the organization and management of the Department's fleet of vehicles and equipment. This report summarizes our findings and recommendations.

1. PROJECT BACKGROUND AND OBJECTIVES

The Department of Highways owns, operates and maintains a fleet of vehicles and equipment that is used throughout the state. Top managers in the Motor Pool and Equipment Division, as well as in the Department of Highways, have recognized a need to improve the way the Department's equipment is managed. This need for improved management is further highlighted by the Legislative Fiscal Analyst Report of January 1981 - Budget Analysis, 1983 Biennium, which recommends that the Department conduct a thorough assessment of equipment needs.

The need to make improvements in equipment management is a result of the increasing inability of the Department to adequately maintain, replace, operate and account for the costs of fleet. The inability to fund, budget and otherwise account for equipment expenditures has created inconsistent replacement of the fleet, resulting in many units that have exceeded their economic life. Also, mid-year adjustments in rental rates have occurred, creating an unexpected demand on the budgets of the fleet users. Unclear organizational relationships are causing problems in communications, resulting in increased equipment downtime and inconsistent maintenance practices.

The study involved interviews with headquarters staff, and field management personnel in Great Falls, Helena, Bozeman and Billings. Also, the data collection phase of the project included a review of the various forms, reports, memos and other department records associated with the management of the fleet. But the primary source of information and direction came from the extensive research and review conducted by the Equipment User Steering Committee.

Recommendations in this report are based on the field research, User Steering Committee efforts, on our experience with the "state-of-the-art" in equipment management in other state agencies, and through research conducted by organizations such as the Federal Highway Administration and the American Public Works Association.

2. SUMMARY OF RECOMMENDATIONS

The study identified a number of needs that, if not satisfied, will continue to limit the Department's ability to effectively manage the fleet.

The User Steering Committee reviewed several approaches to meeting the critical needs, and selected one alternative: It recommended that the Department develop and implement an equipment management system. The Committee suggested that the new system be based on the following priority - ranked actions.

One: Revise the existing equipment enterprise fund, to totally fund all costs of equipment operation, maintenance, replacement and administration.

+ Revise the existing rental rate system to support the revised equipment fund; and

+ Develop procedures to determine replacement needs, based on economic life-cycle costs.

Two: Revise and expand the existing information system, to provide information relative to:

+ equipment performance;

+ shop performance; and

+ fund accountability.

Organize data input and processing procedures, and improve output formats -- to ensure that the information is timely and directed toward management decision-making.

Three: Standardize equipment maintenance practices and procedures statewide through:

+ improving existing preventive maintenance and servicing procedures;

+ improving shop scheduling procedures;

+ mechanic training; and

+ increased control of parts supply and availability.

A key element in standardizing maintenance practices involves developing and implementing an operator training program directed toward proper operation and servicing of equipment. (This program is now being developed by the Maintenance Division.)

Four: Continue the recent efforts to reshape the organization of the Motor Pool and Equipment Division, by assigning responsibility for the (field) inventory of parts and supplies to equipment maintenance shop foremen.

It is also recommended that Department managers consider concurrent development and implementation of systems for road maintenance management and equipment management.

3. SUMMARY OF BENEFITS AND COSTS

Implementation of an equipment management system will provide clear, tangible benefits:

- Total Equipment Funding

  The benefits from adopting a total fund concept provides a stable equipment replacement cycle, based on the economic life of each unit -- rather than on the current status of the earmarked revenue account. Total equipment funding takes equipment replacement decisions out of a situation where equipment managers are competing each year for funds, and encourages replacement decisions that are based purely on equipment performance. The end result is an up-to-date fleet that can perform better, cost less and increase user productivity.

- Improved Information

  An improved management information system (actually a subsystem) will result in better decisions regarding equipment performance, shop scheduling, PM compliance and the level of maintenance being performed on the fleet. The information system will reduce the need for manually keeping separate records and reduce the excessive time (and cost) required to get data into, and information out of the system.

- Increased Operator Awareness

  A training program now being designed to increase awareness of operator responsibility and proper use of equipment will result in reduced accidents and equipment abuse, increased life and availability of the equipment and reduced costs. Also, we would expect an increase in the morale and job satisfaction of equipment operators and shop mechanics, and most importantly, a safer operation.

- Reduced Costs

  Our research, supported by similar studies in other state highway agencies, indicates that increased performance will result in a reduction of the total cost of owning, operating and maintaining equipment -- by 5 to 13 percent. We expect that increased performance will occur through (1) better utilization of shop personnel, (2) proper planning and scheduling, (3) better control of the stockrooms, (4) increased management and technical skills and (5) reduced equipment downtime, through a reduction in the age of the fleet, and through standardized maintenance practices.

A conservative estimate of the total annual savings associated with system implementation -- using 5 percent rather than 13 percent of the total budget -- indicates that the Department can reduce total equipment costs by about $380,000 per year. Over a five-year period, we expect a cost savings of nearly $2 million -- a savings of more than eight times the cost of $247,000 for developing and implementing the new system.

II. SUMMARY OF FINDINGS

The needs of the Department regarding equipment management are presented by defining the current system and the procedures being used: specific needs and potential improvements in equipment management practices are provided. We also define specific requirements of an equipment management system that will satisfy the needs.

1. OVERVIEW OF CURRENT EQUIPMENT SYSTEM AND PROCEDURES

This overview describes the Department's fleet responsibility, organization, current funding and budgeting procedures, maintenance and repair procedures, and the existing information system.

- Scope of Fleet Responsibility

  The department operates and maintains a fleet of about 3,300 vehicles, assigned to various locations throughout the state. The distribution of the divisions that use the fleet is as follows:

+	Maintenance	83%
+	Construction	15%
+	Other	2%

  Also, the Department operates and maintains a motor pool, used by all state departments. There are approximately 250 units currently assigned to the motor pool.

- Organization

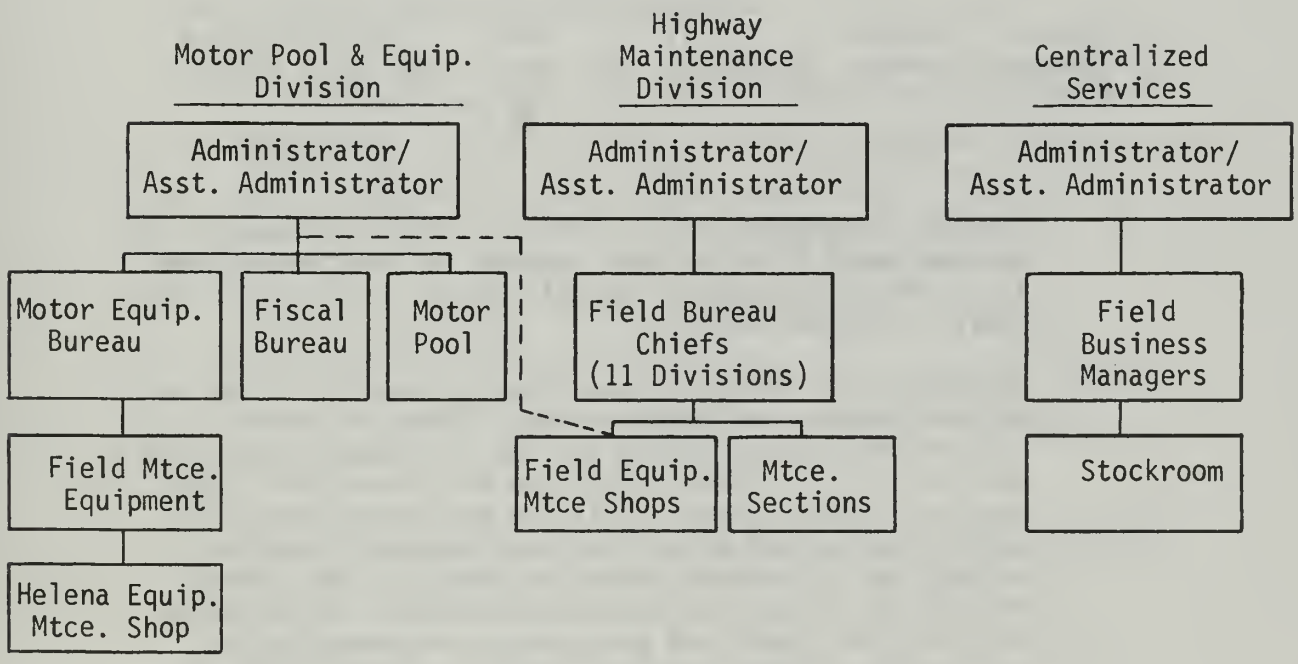
  The management of the fleet is spread among three divisions within the Department -- Motor Pool and Equipment, Maintenance Division and Centralized Services. The Motor Pool and Equipment Division has primary responsibility for planning, organizing and monitoring of the fleet. The Division has direct maintenance responsibility for heavy, specialized equipment that is beyond the capability of the field

maintenance shops. It is also responsible for shared equipment. The administration and maintenance of the state motor pool is also a responsibility of this division. The Highway Maintenance Division is performing the function of day-to-day administration and supervision of the field maintenance shops. Centralized Services supports the fleet management by such administrative services as input of equipment usage data, purchasing and stockroom support.

There are differences between the way the responsibility for the fleet is officially organized and the way it is currently functioning. Exhibit 1 shows how equipment management is organized "on paper."

Exhibit 1

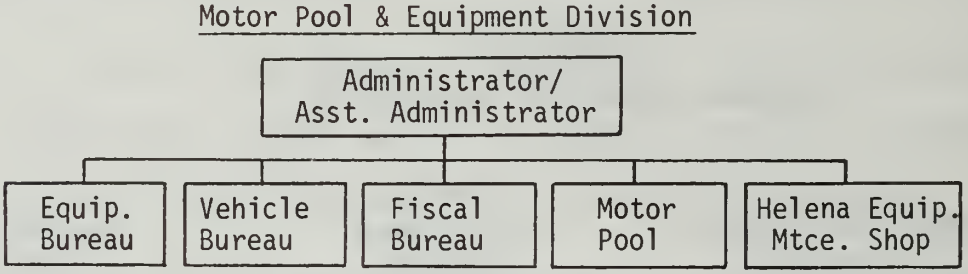
EQUIPMENT MANAGEMENT ORGANIZATION



The organization structure shown in Exhibit 1 is obviously simplified, but shows the major relationships between the divisions, bureaus and field personnel. The organization structure that currently exists in the Motor Pool and Equipment Division is different from the structure shown in Exhibit 1. A more realistic picture of how that Division is currently functioning is shown in Exhibit 2.

Exhibit 2

ACTUAL EQUIPMENT MANAGEMENT RELATIONSHIPS



However, the major organizational differences between how the Equipment Division was intended to function and how it currently is functioning fall in the area of line and staff responsibilities.

As best as can be determined, the Equipment Division was to be organized and function as a "line" division, i.e., to have the responsibility to plan, schedule, direct and control all activities associated with managing a centralized fleet. Certain policies and procedures being carried out by the Motor Pool and Equipment Division reflect basic line management responsibilities; these include the direct supervision and control of the Motor Pool and the repair and maintenance performed by the Helena shop. Also, a policy requiring approval by the Equipment or Vehicle Bureau Chief of any repair performed in the field shops over $250 implies line direction from the Motor Pool and Equipment Division to the field shops. The budgeting for all fleet maintenance, repair, operation and purchasing of new equipment is, again, a typical line management function.

However, the Motor Pool and Equipment Division is, in reality, more of a staff agency. (Typical staff organizations perform such functions that are described as monitoring, reviewing, assisting, and so on.) This staff responsibility occurs in the Division's relationship with other divisions in the Department -- especially Maintenance and Centralized Services. The Bureaus of Equipment (Class 30 and above), Vehicles (under Class 30) and Fiscal basically perform an assistance-type function by working with the field shops in reviewing repair procedures, expediting parts and supply purchases, inspecting and checking for PM and servicing compliance, and coordinating the assignment of state-wide specialized equipment.

The Motor Pool and Equipment Division also develops funding procedures and rental rates for the using division -- to expense the cost of the fleet to the various accounts. The Division Administrator is also involved, along with the Field Maintenance Bureau Chiefs, in hiring Field Shop Foremen, who are directly supervised by the Maintenance Bureau Chiefs.

- Equipment Funding And Budgeting

The Division has the basic responsibility for budgeting for all maintenance, operation, repair and purchasing of equipment. A rental rate system has been established to charge the users of the fleet. This system has a dual rate structure -- using a usage rate (miles or hours) to recover direct operating and maintenance costs. The other part of the dual rate is an assigned rate to recover all indirect, non-reimbursable, insurance and depreciation costs. This assigned rate is an hourly rate, usually charged for all hours a unit is available for use (i.e., 1992 hours per year, less downtime). The rates are established for some 65 classes of equipment -- with some rates set by sub-class.

The depreciation rate is collected as part of the assigned rate, based on expensing the equipment over the estimated life of the unit -- expressed in miles or hours. The planned life ranges from 5 years or 75,000 miles for passenger cars to 12 years or 250,000 miles for larger diesel trucks. For large equipment (Class 30 and above), the life ranges from 15 to 20 years.

Because the rate used to replace the fleet is based on depreciating the current fleet, the funds generated annually through rental have been insufficient to purchase

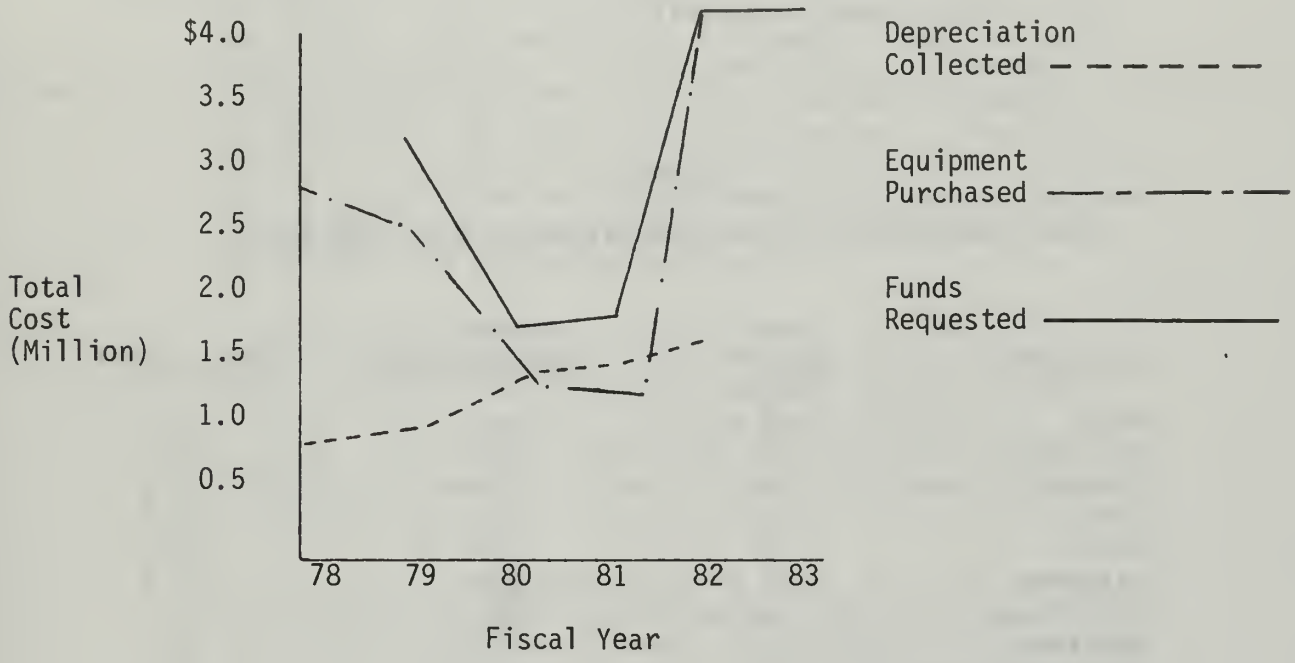
new replacement equipment. Each year, the Division determines the amount of equipment that needs to be replaced (based upon input from the using divisions, and fleet records). The funds required for the current-year purchases are determined and compared to the amount of rental collected through depreciation. The difference between the funds collected and the annual needs for equipment is submitted as a supplemental funding request to the earmarked revenue account. The final equipment replacement list is determined, based on the amount actually appropriated. Once the new equipment has been put into service, the replaced units are sold, and the residual funds are used to offset a portion of supplemental appropriation.

As a result of this system of equipment funding, the average age of the fleet has been steadily increasing. Approximately 15% of the units in the fleet have exceeded their estimated life expectancy. (A one-time replacment of all units that have exceeded their estimated life would cost the Department approximately $9.2 million.) To improve the state of the fleet, the Division requested, and has received approval for a funding level of close to $4 million in both FY 1982 and 1983. This funding level represents the current cost to annually replace the units in the fleet that exceed their estimated life each year. It does not fund any of the backlog of units that have already passed their economic life, nor does it allow for the purchase of additional units beyond the replaced units.

Exhibit 3, on the next page, summarizes the relationship among equipment purchased, depreciation collected, and equipment funds requested by the Division. From FY 1979 to FY 1981, approximately 65% of the Division's replacement requests were funded. (This does not include an additional $682,000 in FY 1979 supplemented over the original approval due to the severe winter. The additional funding brought the FY 1979 level for equipment purchased to the $2,234,000 shown in Exhibit 3.) In FY 1982 and FY 1983, the Division's request for $3,977,000 in each year has been approved and completely funded.

Exhibit 3

RECENT TRENDS IN EQUIPMENT FUNDING



Also, from FY 1978 to FY 1982, the amount of funds generated by the depreciation collected was approximately 49% of the cost of the replacement equipment. The amount of depreciation collected since 1978 has been slightly increasing each year, while the amount of funds requested, and subsequently approved, has had wide variation.

The Division's motor pool unit has added a per mile replacement surcharge to the rental rate charged on motor pool units, to help bridge the gap between funds collected through depreciation and actual dollars needed for replacement units.

- Equipment Maintenance and Repair Procedures

The maintenance and repair function is performed by the various field shops which, with the exception of the Helena shop, are managed directly by the Field Maintenance

Bureau Chiefs. Each shop is supervised by a Shop Foreman, and has assigned to the shop a working shop foreman, mechanics, and servicemen. Exhibit 4 shows the shops where maintenance is performed, current staffing levels, the total number of units being maintained by each shop, and a ratio of the number of units to the assigned staffs.

Exhibit 4

DISTRIBUTION OF EQUIPMENT MAINTENANCE STAFF AND UNITS

Location	Staff	Number of Assigned Units	Units/Staff
Butte	13	417	32.1
Kalispell	9	325	36.1
Bozeman	8	263	32.9
Great Falls	10	336	33.6
Havre	8	240	30.0
Glendive	7	181	25.9
Wolf Point	6	191	31.8
Billings	9	321	35.7
Miles City	6	200	33.3
Lewistown	8	252	31.5
Helena [1]	11	407	37.0
Missoula	10.5	388	37.0
Total	105.5	3521	33.4

[1] Helena shop data includes the Motor Pool vehicles and two servicemen. Also included are 40 units assigned to Butte but maintained in Helena.

The shop scheduling and assignment procedures vary from shop to shop. However, basic priorities are established in line with the seasonal requirements of the equipment. The Division has established servicing and preventive maintenance requirements, with the servicing being an operator responsibility. The interval for

servicing is 5,000 miles; the PM interval is 20,000 miles. The PM and servicing intervals apply only to over-the-road vehicles (under Class 30), as there are no standard PM frequencies for the larger units. Also, there is no standard procedure for performing PM's, as each shop has developed their own procedures.

The basic repair document used by all shops is the Shop Work Order. This Work Order is standard throughout all shops, and summarizes the work done, mechanics' time spent, and the cost of parts used. The Work Order is not being used as input into the equipment or financial systems. Many shops are also using a Maintenance Request form that is filled out by equipment operators (or section foremen), as input for repairs needed. It is also used to schedule the work into the shop.

The shops are supported by stockrooms. The level of supplies carried by the stockrooms vary substantially among locations, with the shop foremen relying heavily on local parts suppliers for such basic supplies as filters, points, belts and hoses. Many of the field shops depend heavily on one of their servicemen to do parts chasing.

For parts costing between $200 to $300, the shop foremen are required to obtain verbal quotes from three suppliers. If the parts cost for a repair is over $300, three written quotes are required, and this is usually handled through purchasing in Centralized Services.

- Information Systems

The Motor Pool and Equipment Division receives a series of reports that provide information regarding equipment operation, utilization and costs. These reports include:

+ Equipment Inventory Management Report. This report summarizes basic inventory data on each unit in the fleet -- such as description, location, year purchased, serial numbers, purchase price, current book value, year-to-date and life-to-date usage.

+ Equipment Operation Cost Report. This report details, by class, all costs of operation, maintenance and ownership, and compares these actual costs to the amount of earnings generated through the rental rates. The costs and earnings are shown both in total dollars and in cost per mile or hour. This report is also summarized by a range of life-to-date usage (i.e., 70,000 to 80,000 miles).

+ Earnings and Cost Report. This report summarizes, both by class of equipment and by location, costs and earnings for both the usage rate and the assigned rate.

+ Monthly Usage Report. This report shows, by unit, the amount of usage reported by month for a 12-month period (latest 12 months).

+ Equipment Utilization Report. This report details, by unit, usage, assigned hours and downtime for the current period, year-to-date and life-to-date.

Also, the fleet users receive the standard accounting and expenditure reports that include equipment expenses, as charged through the rental rates.

The basic input document for equipment usage data is the 905 form. Field equipment operators submit either daily a 901, or monthly a 905, that records mileage and assigned hours. Field office personnel are copying the data onto 905's to be sent in to Helena for input. Equipment costs are collected through the normal accounting input procedures, (i.e., time sheets, vouchers, claims, and so on).

2. OPPORTUNITIES FOR IMPROVEMENT

The User Steering Committee identified several problem areas that are limiting The Department's ability to effectively manage the fleet. The problem areas include (1) inadequate equipment replacement, (2) a lack of timely, appropriate management information, (3) the Division organization, and (4) inconsistent field maintenance and operating procedures. In each of these problem areas, critical needs have been identified that, if not addressed, will continue to limit the ability of the equipment fleet to properly serve the Department.

- Equipment Replacement

A key problem defined by the Committee is inconsistent funding for equipment replacement. A constant theme heard throughout the Department is that the fleet is "getting old." Many units have been kept beyond their economic life, and thus become a burden to the Department, rather than an asset that performs a critical service. The effects of not replacing equipment at the proper time are increased downtime, decreased productivity and increased maintenance and repair costs. Older units break down more often, (and at criticial times), replacement parts are no longer available and these units are not as efficient (or as safe) as newer units.

To make significant improvements in equipment replacement requires efforts in two areas: (1) total equipment funding and (2) replacement decisions based on economic life-cycle costs.

The rental rates now being charged to users recovers a portion at the replacement cost by depreciating the cost of the original unit over its life. Because of the levels of inflation experienced in the equipment industry (especially highway equipment), the funds collected through the depreciation portion of the rental rate are recovering only about 50% of the cost of new replacement equipment. The difference is made up through a supplemental appropriation from the earmarked revenue account.

The concept of total funding implies a rental rate that collects funds, not to depreciate the equipment already purchased, but to charge current operations for future equipment purchases. The objective is to recover the total cost of replacement through the rental rate, without having to rely on earmarked revenue account to each year supplement equipment purchases. This allows the decision -- whether or not to replace a particular unit -- to be based on a true economic life and on the unit's ability to perform, not on the availability of funds, which are subject to outside, political factors and other considerations.

Equipment downtime is a good indicator of the impacts of an aging fleet -- one that is not supported by total funding. As equipment gets older, downtime increases, due to an increase in the frequency of routine repairs, and the need to do major repairs, such as engine and transmission rebuilds and overhauls. Exhibit 5 shows the relationship between downtime and equipment life, by comparing the average year-to-date (FY 1981) downtime

Exhibit 5

RELATIONSHIP BETWEEN EQUIPMENT UNIT AGE AND DOWNTIME

	EQUIPMENT CLASS				
	3 Ton Dump Truck	Motor Patrol	Front End Loader	Pickup	Total
Total Units in Fleet	397	127	193	325	1042
% of Total Fleet	12.1%	3.9%	5.9%	10.0%	31.8%
% of Annual Expenditures	36.5%	7.3%	6.1%	11.0%	60.9%
Estimated Life	9 yrs/ 150,000 mi	20 yrs	20 yrs	8 yrs/ 100,000 mi	
No. Units Exceeding Estimated Life	121	17	8	78	224
% of Units Exceeding Estimated Life	30.5%	13.4%	4.1%	24.0%	21.5%
Avg. YTD Downtime/Unit Class Total (Hrs)[1]	51.9	31.9	23.7	6.5	30.2
Avg. YTD Downtime/Unit Units Exceeding Est. Life (Hrs)	60.5	55.8	8.0	9.1	39.7
% Change - Hrs Downtime	+16.6%	+74.9%	-66.2%	+40%	+31.5%

[1] The average year-to-date downtime hours per unit calculation excludes data from two out of the twelve maintenance divisions, as downtime was not being reported in these two divisions.

per unit for units that have passed their estimated life to the total class average for all units in each class. The data shown in Exhibit 5 includes four key classes of equipment: 3 ton dump trucks, motor patrols, front end loaders and pickups. These four classes, out of a total of 65 classes of equipment, represent 32% of the total number of units in the fleet, (excluding the Motor Pool).

As indicated in Exhibit 5, units that are exceeding their expected life are experiencing over 30 percent more downtime than units operating within an expected life.

Total funding of equipment purchases through adequate rental rates does not automatically solve problems associated with equipment replacement. Good decisions on which units need to be replaced, and how long specific units should be kept in the fleet, also need to be made. This requires management tools that properly analyize equipment performance and costs, to truly define the economic life.

The current "dual rate" system is a good one, and Division managers have been using it effectively. It is similar to a number of effective systems in use by other state highway departments. But clearly, there is need to fully utilize the dual rate aspects associated with the system -- by establishing sound funding policies that ensure adequate revenues for replacement, and establish full internal-fund accountability.

- Management Information

Although a certain amount of good equipment management information is being generated, some basic problems exist. One major concern is that information now received is not timely. This problem occurs not only in the equipment management reports, but also in the financial reports that carry equipment expenses to the users, and in the stock (1350) reports that summarize parts and supply data to the equipment maintenance shops. The timeliness of the reports appears to be dependent upon the data input procedures, which require a series of coding, re-coding, and edits before being entered.

The result is that reports are six to eight weeks old, and are not being used. Instead, a series of independent, manual information systems are being maintained by field office personnel. These systems require excessive time and effort.

There also is a need to provide information that is geared to decision-making. This includes information that is formatted in such a manner that managers will rely on the information to make decisions, based on equipment performance and costs, maintenance, scheduling, and shop procedures. This requires some standardization of information throughout the Department. The information must be compatible with other existing information and accounting systems. Also, managers need the ability to retrieve certain information on an "on-line" basis, rather than waiting for end-of-month batch processing of data.

- Organization

The need for improvement in the organizational structure is evidenced by the inability of the Division to directly control equipment operations and maintenance. Part of the problem is that there is no clear definition of authority and responsibility. Also, communications between the Division and the fleet users, as well as within the Division, is not entirely effective.

Another part of the problem is that the Division is not properly responding to the needs of the fleet users. This is evidenced by delays in performing field maintenance. The delays are frequently caused by approval limits the Division has established. Added to this is the fact that the Maintenance Division, through its field divisions, has essentially been given the responsibility for the day-to-day maintenance of the units assigned to the respective field bureaus. However, as a result of the two divisions being separate organizations, the Maintenance Division is still looking to the Motor Pool and Equipment Division to be responsible for the maintenance of the fleet, but yet this Division has no effective means to directly control the level of maintenance and repair performed in the field, or to define how the units are to be used and operated.

- Field Maintenance and Operation Procedures

During the review of field maintenance procedures, it was apparent that there were wide variations in maintenance practices among the field equipment maintenance shops. The variation occurs in how often preventive maintenance is performed, as well as how it is performed. The Division has established preventive maintenance (PM) and servicing intervals for all equipment class 30 and below, (sedans through motor patrols). These intervals are implemented statewide and are, for the most part, being followed. However, there are no standard PM intervals established for larger equipment, and there are no standard

procedures to follow when performing a PM on any of the equipment classes.

An indicator of non-standard maintenance practices is the amount of time equipment is in the shop for maintenance or repair. In Exhibit 6, the average year-to-date (FY 1981) downtime per unit is shown, for four key classes of equipment: 3-ton dump trucks, motor patrols, front-end loaders and pickups. (Equipment units must be "down" a minimum of four hours before being reported as "down.")

Exhibit 6

	Average YTD Downtime in Hours Per Unit			
Maintenance Shop	3-Ton Dump Truck	Motor Patrol	F.E. Loader	Pickup
Missoula	71	23	15	21
Kalispell	106	44	22	0
Butte	69	76	58	35
Bozeman	25	24	19	1
Great Falls [1]	N/A	N/A	N/A	N/A
Havre	7	0	4	4
Glendive [1]	N/A	N/A	N/A	N/A
Wolf Point	44	27	23	5
Billings	3	0	0	2
Miles City	50	41	26	19
Lewistown	49	38	40	3
Helena	12	0	3	3
Statewide Average	52	32	24	7

[1] Great Falls and Glendive are not reporting downtime.

The significant finding regarding the data in Exhibit 6 is the wide variation in downtime among maintenance shops. For example, in the 3-ton dump truck class (the bulk of the maintenance fleet), the average hours of downtime per unit ranges from 3 hours in Billings to 106 hours in Kalispell, (double the state-wide weighted average). By establishing optimum servicing intervals, for all classes of equipment, and by ensuring that the PM's and servicings being performed are consistent throughout the state, the Department can improve the level of maintenance, reduce the amount of unscheduled repairs due to breakdowns, and get better utilization of equipment shop personnel. The utilization of shop personnel also can be

improved through (1) increased training of mechanics, especially in the proper use of electronic diagnostic equipment, and (2) full use of stockroom and supply personnel in ensuring adequate parts availability. The supply system must also be responsive to the needs of the field shops through improvements in stock levels and parts purchasing procedures.

Finally, there is need not only to define responsibility for the use and ownership of the fleet, but a need to improve and protect the condition of the equipment -- by ensuring that it is operated and serviced correctly by equipment operators. One cause of breakdowns -- and the resulting repairs, downtime, decreased productivity and reduced equipment life -- is a result of accidents and operator abuse, both of which can be prevented. For example, within the past year, 18 "operator-related" equipment repairs were performed, at a total repair cost of $19,000. All 18 repairs were caused by operators not properly servicing, or improperly operating equipment. In addition, repairs were made that normally would have been covered by manufacturer's warranty, but was not properly reported. Naturally, the cost of the repairs had to be absorbed by the Division. Through a program of operator training and awarenes -- now under preliminary development by the Maintenance Division -- occurrences such as these can be reduced significantly.

3. SYSTEM DEVELOPMENT CONSIDERATIONS

Interviews with managers and direction from the User Steering Committee revealed a number of factors that need to be considered in the design of an equipment management system:

- The new information system must be timely, simple to operate and maintain, and completely compatible with all other systems. The system must be designed to help managers make good decisions.
- The system must have the full support and direction from top management, through the establishment of specific policies regarding each element of the new system -- from proper funding through shop scheduling.

- The system will require extensive support from Data Processing -- both in the development and maintenance of new programs, and in the field through the capability to input data directly into the system.

- The new system must be developed to the point where equipment users can establish equipment-related budgets, based on new rental rates, not later than the beginning of 1983 -- to meet Department requirements.

Department managers also should consider concurrent development of systems for road maintenance management and equipment management. There are four reasons: First, some system-related data (such as equipment availability and equipment utilization) originates from the same source and is used by both maintenance and equipment managers. Second, road maintenance budgets contain an important equipment element -- one that has a real impact on road maintenance effort levels. Third, combined systems development and implementation with the same consultant always provides a smooth interface between the two systems -- a real plus for both equipment managers and users. Finally, concurrent projects usually result in reduced project costs, with or without consultant assistance.

III. RECOMMENDED EQUIPMENT MANAGEMENT PLAN

The current management procedures, the defined needs and opportunities for improvements, and the considerations involved with designing and implementing improvements led the User Steering Committee to develop specific objectives to be achieved through an equipment management system. The objectives are as follows:

- Develop and maintain an adequate equipment replacement program, appropriately funded and based on economic life-cycle costing.
- Refine current rental rate procedures, to recover the cost of equipment operation, maintenance and replacement.
- Provide the information needed to improve management decisions by:
  - + refining and supplementing existing equipment management reports -- to provide decision-making information; and
  - + having an information system that is timely, consistent in context, and compatible with other Department information and accounting systems.
- Increase the effectiveness and responsiveness of the equipment management organization by:
  - + defining and clarifying equipment management policies and procedures;
  - + clarifying lines of authority and responsibility for equipment management;
  - + promoting a high level of consistency in field operations and practices;
  - + ensuring that equipment management procedures are compatible with the inventory stores system; and
  - + improving the communications between all levels of equipment users, managers and staff organizations.
- Increase equipment availability and reduce equipment costs through effective training in both equipment operation and maintenance practices. (In part, this objective will be achieved by the Maintenance Division's new operator training effort.)

An equipment management system designed to achieve these objectives should provide for three broad elements:

1. Appropriate equipment funding;
2. Standard maintenance practices; and
3. Useful management information.

Each of these elements is described in the following sections.

1. EQUIPMENT FUNDING

The proposed equipment management system should include an expansion of the existing enterprise fund for equipment -- to cover all costs of owning, operating and maintaining the fleet. This fund would be similar to current funding, with two main exceptions:

1. The fund should recover, through the rental rates, the total cost of equipment replacement; and
2. The fund should be separated into two sub-funds -- one for replacement and one to cover ongoing operation, maintenance and administrative costs.

The major change in funding would be to calculate the assigned rental rate based on a cost of replacement, rather than a depreciated cost of the original unit. It would still be necessary to account for depreciation of the fleet, as book value is still important from the standpoint of accountability. However, the account records should include a "Replacment Reserve" account -- to properly show the amount collected over and above depreciation. Also, any residual value received from the sale of used equipment should go back into this fund, to offset a portion of the replacement reserve. The recommendation to segment the equipment fund into separate funds -- one

for ongoing operations and one for replacement -- is based on the need to prevent any erosion of the replacement reserve from deficits in ongoing operations. The two sub-funds need to be accounted for individually.

To implement this "total funding" strategy, the equipment management system should provide for:

1. top management policy direction -- to restructure the existing equipment enterprise fund.
2. review and revision of the rental rate system -- to fully support total funding concepts; and
3. revised depreciation schedules -- to more accurately define current book value, (based on acceptable practices).

The other side of the funding coin consists of a series of actions that must be taken relative to equipment replacements. At least four actions are appropriate:

1. Conduct replacement analyses based on economic life-cycle costs.
2. Analyze equipment performance by class, individual unit and repair components -- to ensure that the type of equipment purchased can best serve the fleet users, at an optimum cost to the Department.
3. Optimize the fleet size and equipment assignment, based on planned utilization levels (from other systems, such as maintenance management), for the various users and locations.
4. Conduct analyses of other options -- leasing, lease-purchase arrangements and short-term rental.

Most of the data needed to carry out these actions is provided through the information system, (described below).

2. STANDARD MAINTENANCE PRACTICES

This element addresses the need to increase the effectiveness of people who operate and maintain Department equipment. The equipment management system should provide specific procedures to improve maintenance practices, improve the condition of the fleet, facilitate communication among equipment and shop staff and fleet users, and improve availability through decreased downtime. Operation, maintenance and repair elements of an equipment management system should include:

1. Standardized PM and servicing intervals and procedures, for all equipment classes;
2. Improved shop scheduling procedures;
3. Formal training of shop mechanics to upgrade skills, and to encourage better utilization of existing skills; and
4. Effective parts inventory management.

3. MANAGEMENT INFORMATION

An equipment management system must provide appropriate management information -- information that is timely, directed toward decision-making and is compatible with other Department systems.

As we see it, existing reports simply need to be refined -- to achieve system objectives. The vast majority of the refinements should result in "exception reports" -- highly summarized pictures relating to equipment performance, shop performance and financial

or cost-related matters. A variety of reports can be created to satisfy "decision-making" needs. Examples of these kinds of reports are provided in Exhibits 7 through 11:

- Exhibit 7 -- a typical fleet performance and cost summary. This report shows, on one page, the overall status of each class of equipment, in terms of revenues being collected, costs incurred, average availability and average utilization. A statewide summary, also on one page, can provide the numbers needed to highlight potential problem areas.

- Exhibit 8 -- a typical "call back" report. This report isolates "repeat" repairs on specified equipment components. It is designed to help shop foremen isolate potential problems -- in mechanic performance and component quality.

- Exhibit 9 -- a typical preventive maintenance (PM) needs report. The PM needs report simply serves as a reminder of the need for servicing and/or PM work. It is designed for use as a worksheet, and as an aid in shop scheduling,

- Exhibit 10 -- a typical equipment downtime summary. This report shows the units of equipment that are experiencing relatively high amounts of downtime. In the example, six units account for 75 percent of the downtime. (The remaining 25 percent of the total downtime is probably spread among 30 to 50 units.) As with other exception reports, this one is designed to highlight problem areas and to focus management attention on significant exceptions to the norm.

- Exhibit 11 -- a typical report on equipment replacement recommendations. This report provides a unique priority listing of the units of equipment that should be replaced. It is unique in that actual, average annual costs of owning, operating and maintaining a given unit are compared, side-by-side, with the estimated cost of owning, operating and maintaining a comparable new unit. It also provides some indication of the annual amount of money that would be saved by replacing a given unit.

Once again, these reports are simply illustrative of the kinds of reports that can be developed to help managers make good decisions.

Exhibit 7

TYPICAL FLEET PERFORMANCE AND COST SUMMARY FOR ONE DISTRICT
(ROLLING 3-MONTH AVERAGE)

EQUIPMENT MANAGEMENT SYSTEM

REPORT PERIOD: 4/1/81 TO 6/30/81
RUN DATE: 7/15/81

EQUIPMENT CLASS	TOTAL UNITS	HOURLY REVENUE	HOURLY COST	PERCENT AVAILABLE	PERCENT USE
SUB-COMPACTS	8	.20	.18	98	65
COMPACT SEDANS	3	.22	.22	97	85
INTERMEDIATES	10	.24	.24	99	71
COMPACT PICKUPS	3	.17	.23	94	93
1/2 TON PICKUPS	2	.31	.30	98	67
3/4 TON PICKUPS	3	.30	.31	97	91
CREW CABS	2	.36	.40	96	86
5-6 YD DUMP TRUCK	15	16.00	11.59	95	47
8-12 YD DUMP TRUCK	27	17.00	18.50	84	45
WATER TRUCKS	7	20.00	34.08	96	05
MISCELLANEOUS TRUCKS	26	17.01	25.27	87	21
GRADERS	13	19.00	15.70	94	56
SMALL LOADERS	12	30.00	39.36	86	09
LARGE LOADERS	4	42.00	52.15	92	11
D5 & D-6 CRAWLER CAT	1	32.00	30.38	100	10
D-8 CRAWLER CATS	3	58.00	55.01	67	40
GRADALLS	3	24.00	25.25	79	61
ROLLERS	7	13.00	19.63	98	06
MISCELLANEOUS HOURLY	13	26.34	28.26	93	16

% AVAIL. LIGHT: 97 (3 MO)

% AVAIL. HEAVY: 89 (3 MO)

Exhibit 8

TYPICAL EQUIPMENT CALL BACK REPORT
FOR A FIELD MAINTENANCE SHOP

EQUIPMENT MANAGEMENT SYSTEM

PERIOD FROM 10/1/80 TO 12/31/80
RUN DATE 1/12/81
PAGE 1

EQUIPMENT UNIT NO.	DESCRIPTION	WORK ORDER DATE	DOCUMENT NUMBER	COMPONENT/REPAIR TIME CODE	DESCRIPTION	HOURS WORKED	MAINTENANCE COST LABOR	PARTS	COMM	TOTAL
3312	INTL TRACTOR	10/ 4/80	10522	13	HYDRAULICS	2	82	9		91
		10/16/80	10815	13	HYDRAULICS	5	158	30		188
		10/21/80	12881	13	HYDRAULICS	3	88	40		128
		10/10/80	14002	31	BATTERY	1	33	3		36
		10/12/80	14032	31	BATTERY	2	88	20		108
						13	480	102		582
411	DODGE 1-TON	10/ 6/80	10811	33	STARTING	3	104	61		165
		11/ 1/80	14663	33	STARTING	2	81	211		292
		11/ 3/80	14811	33	STARTING	6	226	104		330
						11	311	326		787
3620	INTL DUMP	10/ 7/80	10820	62	FUEL SYSTEM	4	134	31		165
		10/21/80	12886	62	FUEL SYSTEM	3	102	64		166
						7	236	95		331
3622	INTL DUMP	10/15/80	10801	25	SVC BRAKE	5	162	180		342
		11/ 7/80	14812	25	SVC BRAKE	3	101	--		101
		11/ 7/80	14812	62	FUEL SYSTEM	1	31	3		34
		11/16/80	15622	62	FUEL SYSTEM	2	84	14		98
						11	268	187		575

Exhibit 9

TYPICAL PM NEEDS REPORT

FOR A FIELD MAINTENANCE SHOP

EQUIPMENT MANAGEMENT SYSTEM

RUN DATE: 4/21/81
PAGE 1

THE UNITS LISTED BELOW NEED SERVICING OR PREVENTIVE MAINTENANCE ATTENTION, BASED ON GUIDELINES PROVIDED IN THE EQUIPMENT MANAGEMENT MANUAL

EQUIPMENT UNIT NO.	DESCRIPTION	UNIT LOCATION	SERVICING AND PM INTERVALS SERVICE A	SERVICE B	PM	RECENT MI/HR	TYPE OF SVC/PM DUE*	REMARKS/ACTION TAKEN
3087	INTL CARRYALL	PATROL 7	6,000 MI	10,000 MI	ANNUAL	78,202	A - 6,622 PM - 3/81	
3312	INTL TRACTOR	PATROL 7	6,000 MI	12,000 MI	SEMI	36,211	B - 12,655 PM - 2/81	
3622	INTL DUMP	PATROL 6	6,000 MI	12,000 MI	ANNUAL	42,868	A - 7,003	
3641	INTL DUMP	PATROL 8	6,000 MI	12,000 MI	ANNUAL	56,200	PM - 2/81	
3823	DODGE DUMP	PATROL 8	6,000 MI	24,000 MI	ANNUAL	31,051	A - 6,822	
6100	GRADALL (UNIT)	PATROL 7	50 HR	250 HR	QUART	3,033	A - 108 B - 281	
7224	JD TRACTOR	PATROL 6	100 HR	200 HR	SEMI	14,332	A - 150 B - 228 PM - 3/81	

*VALUES IN THIS COLUMN REPRESENT USAGE SINCE THE LAST SERVICE, AND THE MONTH AND YEAR WHEN THE LAST PM WAS DUE.

Exhibit 10

TYPICAL EQUIPMENT DOWNTIME SUMMARY FOR SELECTED UNITS IN ONE DISTRICT

EQUIPMENT MANAGEMENT SYSTEM

PERIOD FROM 1/1/81 TO 6/30/81
RUN DATE: 7/15/81
PAGE 1

UNIT LOCATION	EQUIPMENT UNIT NO.	EQUIPMENT UNIT DESCRIPTION	NUMBER OF DAYS DOWN LAST QTR	NUMBER OF DAYS DOWN YTD	NUMBER OF DAYS DOWN FOR LIFE	DOWN FOR COMPONENT/ REPAIR TYPE CODES	MAINTENANCE COST SUMMARY LAST QTR	MAINTENANCE COST SUMMARY YTD	MAINTENANCE COST SUMMARY LIFE
PATROL 17	3312	INTL TRACTOR	38	112	402	3, 17, 31, 44	1,233	611	18,404
PATROL 18	3120	JD LOADER	42	122	368	18, 34, 56	985	2,164	17,888
PATROL 18	3622	INTL DUMP	41	83	341	17, 22	644	821	17,812
PATROL 20	3631	INTL DUMP	30	62	312	14, 34	1,721	2,088	17,911
PATROL 21	3633	INTL DUMP	21	60	288	2, 6, 9, 15, 17	605	1,608	12,331
PATROL 17	6102	GRADALL	7	41	201	33	108	3,402	23,405
TOTAL DAYS DOWN FOR THESE UNITS			149	480	1,912				

NOTE: UNITS LISTED ON THIS REPORT REPRESENT 75% OF THE TOTAL DOWNTIME IN DISTRICT 05.

Exhibit 11

TYPICAL REPORT ON EQUIPMENT REPLACEMENT RECOMMENDATIONS:
1980-81 FOR ONE DISTRICT

EQUIPMENT MANAGEMENT SYSTEM

RUN OATE: 2/1/81
PAGE: 1

REPLACEMENT PRIORITY	EQUIPMENT UNIT NO.	DESCRIPTION	UNIT LOCATION	AVERAGE ANNUAL COST OLD	NEW	CUMULATIVE COST SAVINGS	REPLACEMENT COST THIS UNIT	CUMULATIVE
1	3312	INTL TRACTOR	PATROL 17	4,550	3,000	1,550	6,020	6,020
2	3042	JD BACKHOE	PATROL 22	6,800	5,200	3,150	19,800	25,820
3	3087	INTL CARRYALL	DIST 05	5,500	4,300	4,350	8,100	33,920
4	3221	INTL DUMP	PATROL 17	8,200	6,100	6,450	31,640	65,560
5	3229	INTL DUMP	PATROL 18	7,600	6,100	7,450	31,640	97,200
6	3822	INTL OUMP	PATROL 18	7,200	6,100	8,550	31,640	128,840
7	4221	AW GRADER	OIST 05	14,300	10,800	12,050	71,600	200,440
8	4236	CAT GRADER	PATROL 19	12,800	10,800	14,050	71,600	272,040
9	6122	GRADALL	DIST 05	17,600	11,200	20,450	82,500	354,540

NOTE: RENTAL RATES FOR FY 1981-82 WILL PROVIOE $360,000 FOR EQUIPMENT REPLACEMENT IN DISTRICT 05

Exhibit 12 illustrates one of the key documents in any equipment management system -- a shop (or garage) work order. Notice that the work order is designed to collect all of the costs associated with a given repair. (We do not recommend using this particular work order since it reflects a manual pricing of the work. It is included in this report to indicate the capability of a work order to capture actual costs.)

The new information system (or sub-system) should meet three operational criteria:

- There needs to be a certain degree of on-line data-retrieval capabilities. Some of the data should be available on screen listings.
- Input procedures must be designed to minimize errors, and eliminate duplication and excessive handling of data.
- Cost data must represent real numbers -- actual dollars, and must serve cost accounting and financial accounting purposes.

4. CONCEPTUAL DESIGN

The way in which the three main elements of the system inter-relate with supporting elements and other Department functions is illustrated in Exhibit 13. The relationships shown in this exhibit tend to be over-simplified, and are not precise. For example, the relationship between "accounting" and "replacement funding" is far closer than implied in Exhibit 13. Precise relationships -- both organizational and supporting relationships need to be spelled out during system development.

Exhibit 12

TYPICAL MAINTENANCE WORK ORDER

GARAGE WORK ORDER

EQUIPMENT MANAGEMENT SYSTEM

PARTS RECORD

RECEIVED ORDERED	HOURS WAITING	QTY	DESCRIPTION	TOTAL COST
REC. 10:30 ORD. 9:30	1	2	REAR BRAKE SHOES	10 33
REC. ORD.				
REC. ORD.				
REC. ORD.				
REC. ORD.				
REC. ORD.				
REC. ORD.				

TOTAL HOURS WAITING PARTS 1 — PARTS COST 10 33

TIRE & TUBE RECORD

QTY	DESCRIPTION	TOTAL COST

TIRE COST

LUBRICANT RECORD

QTY	DESCRIPTION	TOTAL COST
	QTS. - MOTOR OIL ●	
	PTS. - HYDRAULIC OIL ●	
	PTS. - GEAR OIL ●	
	QTS. - A.T.F. ●	
	●	

LUBRICANT COST

REQUEST TO EXCEED $250.00

AMOUNT REQUESTED $ _____

APPROVAL

FILE COPY

WORK CODES

REPAIRS:
20 ENGINE
21 CLUTCH
22 POWER TAKEOFF
23 TRANSMISSION
24 DRIVELINE
25 DIFFERENTIAL
26 COOLING SYSTEM
27 ELECTRICAL SYSTEM
28 STEERING & FT AXLE
29 FRAME & SUSPENSION
30 FUEL SYSTEM
31 HYDRAULIC SYSTEM
32 BRAKES & AIR SYSTEM
33 BODY & CAB
34 CUTTING EDGES & BLADES
35 BUCKETS & ATTACH.
36 TIRES, TUBES & TRACKS
37 MINOR P.M.
38 MAJOR P.M.
39 LUBE & OIL
40 INSPECTION
49 ROAD CALLS & TOWING
49 OTHER REPAIR WORK

EQUIPMENT SERVICING:
60 FUELING
61 WASHING
62 PAINTING
63 DAILY P.M.'S
64 COMPONENT REBLD.
65 TIRE REPAIR
69 OTHER SERVICING

SHOP OVERHEAD:
70 GENERAL MTCE.
71 WAITING PARTS
72 WAITING WORK
73 MEETING & TRAINING
74 SUPERVISION
79 OTHER OVERHEAD

LEAVE:
80 WITH PAY
81 WITHOUT PAY

ASSISTANCE TO OTHERS:
90 ROUTINE
91 SPECIAL REQUEST

WORK ORDER	EQUIP. DEPT.	CLASS NO.
9235	121	48 1 0049

METER	EQUIPMENT DESCRIPTION
32123.	PICKUP

CHECK (√) APPROPRIATE ACTIVITY

01		PREVENTIVE MTCE	07		TIME REPLACEMENT
02	✓	UNSCH REPAIR	09		[illegible]
03		MAJOR REPAIR	10		[illegible]
04		COMMERCIAL REP	11		[illegible]
05		ACCIDENT REP	12		[illegible]
06		EQUIP MODIF			

DATE	MONTH	DAY	YEAR	TIME
ENTERED SHOP	07	01	82	0900
PROMISED OUT				1600
WORK STARTED				1100
WORK COMPLETED				1500

LABOR RECORD

INSTRUCTIONS	WORK CODE	I.D. NO.	STANDARD HRS.	TIME OFF / TIME ON	ACTUAL HRS.
REMOVE AND REPLACE REAR BRAKE SHOES & OVERHAUL CYLINDERS	32	16	5.1	OFF 1500 ON 1100	4.0
				OFF ON	
				OFF ON	
				OFF ON	
				OFF ON	
				OFF ON	

MECHANIC — BRING TO THE ATTENTION OF YOUR SERVICEMAN ANY WORK REQUIRED THAT IS NOT DESCRIBED ON THIS WORK ORDER.

B. Friendly
SERVICE ADVISOR

J. Byrd
FOREMAN

TOTAL STANDARD HOURS	5.1	TOTAL ACTUAL HOURS	4.0

DOWNTIME SUMMARY		COST SUMMARY	
HOURS IN SHOP	6	LABOR	40.00
HOURS WAITING PARTS	1	PARTS	10.33
HOURS WAITING WORK	1	TIRES & TUBES	—
HOURS WORKING	4	LUBRICANTS	—
PROMISED OUT (1=MET 2=NOT MET)	1	TOTAL	50.33

Exhibit 13

CONCEPTUAL DESIGN: EQUIPMENT MANAGEMENT SYSTEM

GANIZATIONAL
LATIONSHIPS

ANAGEMENT
YSTEM
LEMENTS

UPPORTING
RELATIONSHIPS

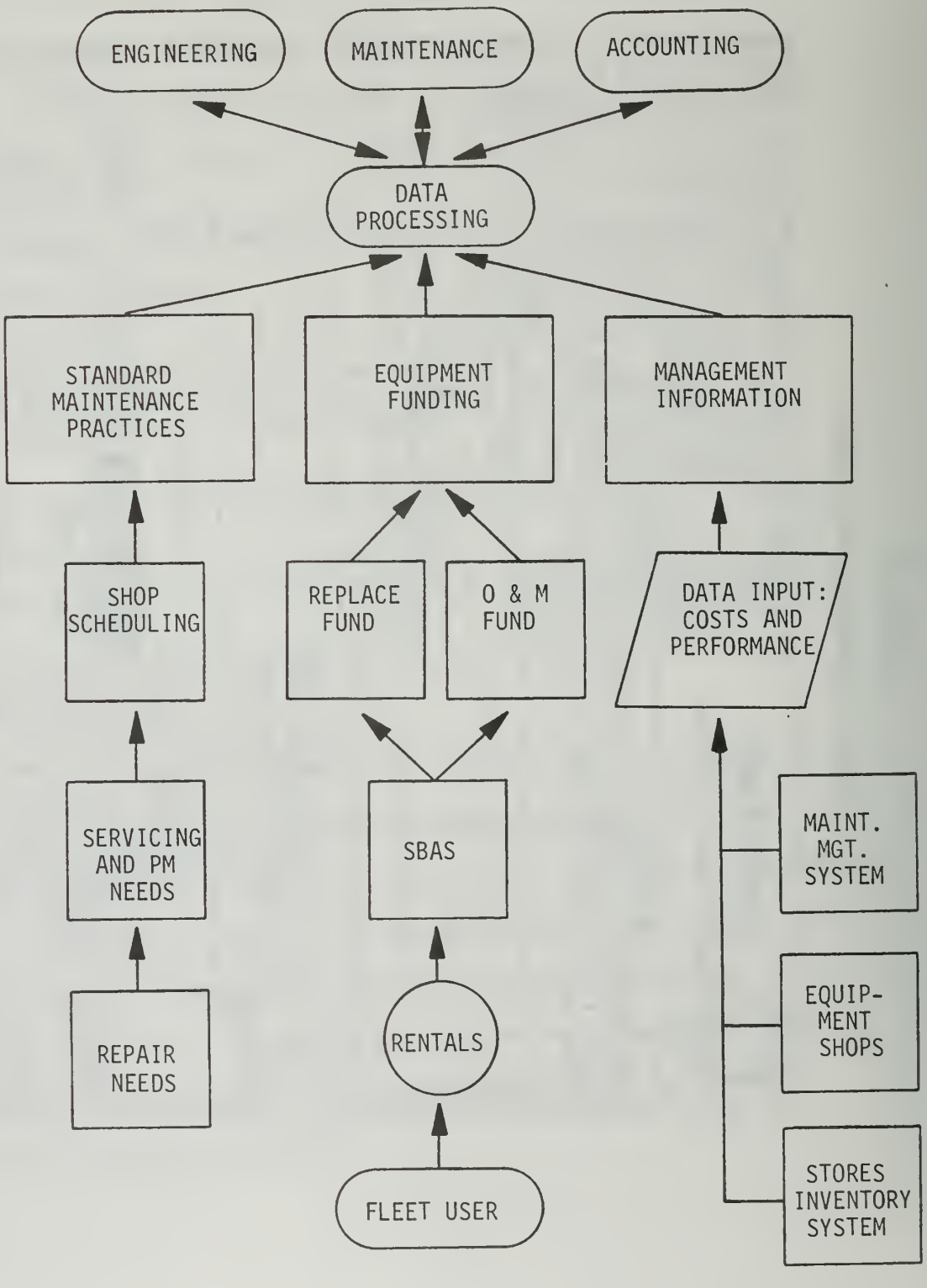


Exhibit 14 provides a conceptual plan for processing data through the equipment management system. It illustrates, in general, the kinds of input, processing, filing and output that are required to support the new system. As with Exhibit 13, the diagram is not precise. Report titles, for example, only suggest the nature of the kinds of information that will be useful.

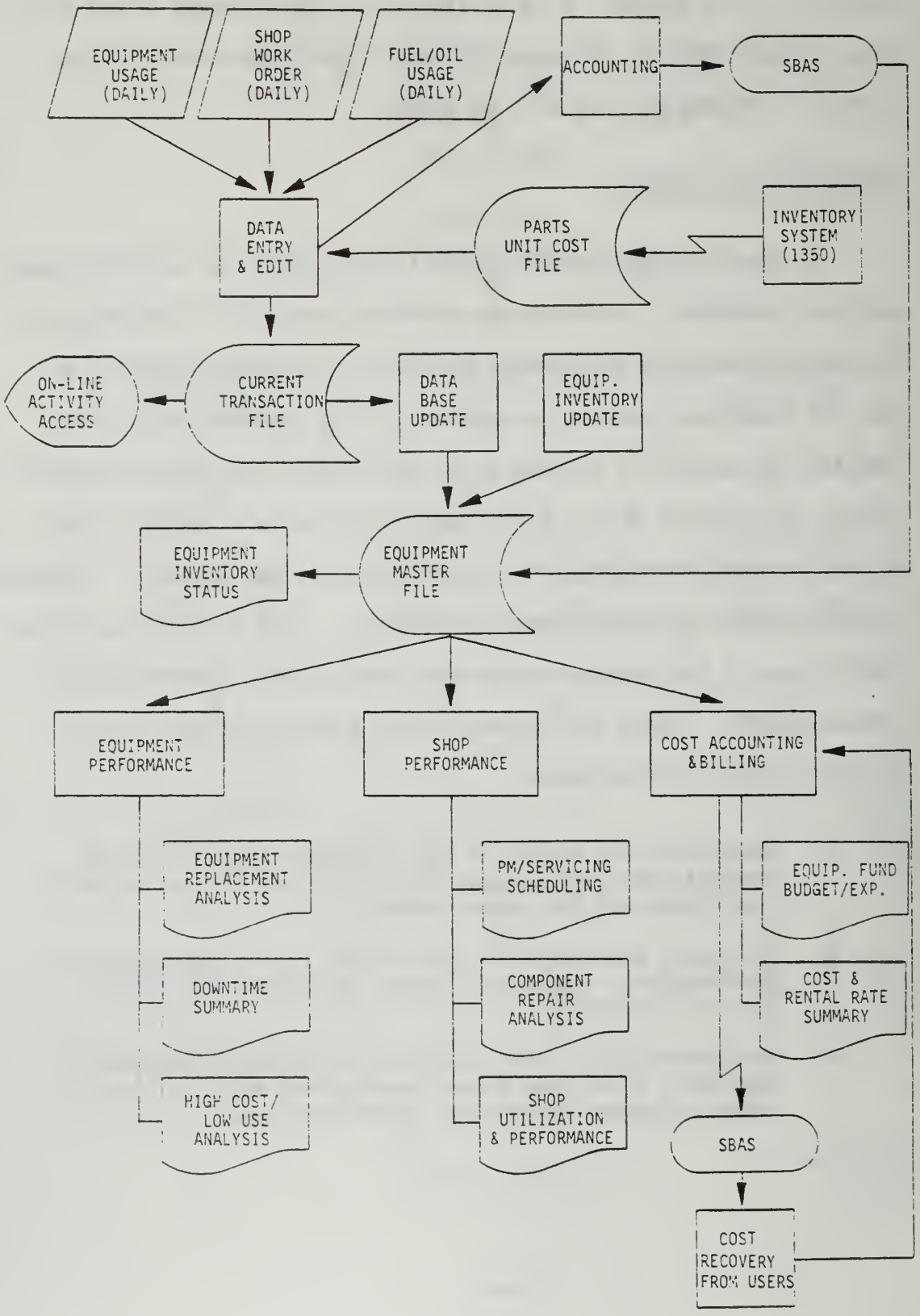
5. ORGANIZATIONAL SUPPORT

The above recommended system will work within the current organizational structure, or within any modified structure. (An effective equipment management system must be able to function regardless of how the Department chooses to organize.) The organizational needs outlined in Section II are now being satisfied. The recent reorganization of the Motor Pool and Equipment Division is a positive step. By reorganizing the headquarters staff into two key bureaus -- Equipment Services, and Fiscal/Management Information -- the Division has eliminated some of the problems associated with unclear authority and responsibility. These two bureaus can be effectively utilized to perform several key functions:

- Monitoring the status of the equipment fund, reviewing expenditures and revenues generated, and the review and development of the rental rates;
- Reviewing and analyzing information regarding equipment performance -- to ensure proper assignment and utilization of the fleet;
- Developing state-wide equipment replacement programs -- including finalizing annual replacement needs and developing equipment purchasing specificiations:

Exhibit 14

CONCEPTUAL DESIGN: INFORMATION/DATA FLOW



- Monitoring field and shop performance - to assist field maintenance shops in obtaining parts, PM and servicing schedules, and providing technical assistance on major repairs;

- Serving as a major focal point for all information concerning the management of the fleet; and

- Developing mechanic and operator training programs, and other communicative devices such as shop foremen meetings, user committees, and so on.

One other organizational change should be made: assign responsibility for operation of the field stockrooms to the Equipment Maintenance Shop Foreman. This move will provide improved control of the inventory system, and will allow greater flexibility in utilizing stockroom personnel to assist in the day-to-day operation of equipment maintenance shops.

IV. ANALYSIS OF ALTERNATIVES

There are several approaches the Department can take to implement improvements in equipment management. The alternatives available to the Department have varying costs and levels of effort required. Also, the results achieved, as measured against the objectives defined in the previous section, will vary greatly. This section describes each alternative -- its estimated cost to implement, and the extent to which the alternative will meet the needs of the Department.

1. ALTERNATIVE I - COMMERCIAL SYSTEM

There is available on the market several commercial equipment information systems that are used by both governmental agencies, and by private fleets. These systems utilize standardized input and output formats, and provide centralized data processing for client agencies.

The information received through this type of system varies, but usually includes:

- Equipment costs and usage, by unit, class and component;
- Equipment billing and accounting information;
- Shop maintenance and repair performance data; and
- Downtime and equipment availability information.

The estimated cost for this type of system for the Department would be as follows:

Initial One-time Costs	
(Training and System Set-up)	$ 10,000
Annual Costs	
Information System ($2.25/unit/month)	96,000
Forms ($1,000/month)	12,000
Total Annual Costs (following system Set-up)	$108,000

Offsetting costs the Department would save are:

Annual Data Processing	$10,000
Forms/Printing	5,000
Total	$15,000

Net Annual Cost: Alternative I - $93,000

The disadvantages of this alternative rest in the fact that it is purely an information system, and does not start to address other needs, such as improved maintenance practices, equipment funding, training and improved organizational support. Also, the information by commercial firms cannot be tailored to the specific needs of the Department. Because all input documents are shipped out of state for processing, the reports are usually not timely.

2. ALTERNATIVE II - DEPARTMENT-DEVELOPED SYSTEM

The second alternative is to develop an equipment management system specifically designed to meet the needs and requirements of the Highway Department. Developing and implementing this system would take approximately 1,200 man-days of effort, over a 14-month period, and a total estimated cost of $246,900. The details of these estimates are shown in Exhibits 15 and 16, and represent a level of effort designed to meet all of the defined objectives.

Exhibit 15

PRELIMINARY MAN DAY ESTIMATE
FOR A 14-MONTH PROJECT TO DEVELOP AND IMPLEMENT
A NEW EQUIPMENT MANAGEMENT SYSTEM
(EXCLUDING PARTS/SUPPLIES INVENTORY MANAGEMENT)

Individual or Group	Estimated Man Days
Administrator, Motor Pool & Equipment Division	30
Project Coordinator/Director	250
Other Headquarters Personnel (typing, clerical and other)	50
Data Processing Staff (1 person) [1]	200
Shop Foremen (11 people)	77
Other Field Support (primarily field bureau chiefs and business managers)	220
Mechanics (105 people/1 day for training)	105
Advisory Committee (5 people/4 meetings)	20
Steering Committee (8 people/5 meetings)	40
Consultant Assistance	220
Total Estimated Man Days	1,212

[1] Assumes refinements to existing reports and development of 5 to 7 new reports.

Exhibit 16

PRELIMINARY COST ESTIMATE
FOR A 14-MONTH PROJECT TO DEVELOP AND IMPLEMENT
A NEW EQUIPMENT MANAGEMENT SYSTEM
(EXCLUDING PARTS/SUPPLIES INVENTORY MANAGEMENT)

Individual or Group	Approximate Total Cost
Administrator, Motor Pool & Equipment Division	$ 5,760
Project Coordinator/Director	22,000
Other Headquarters Personnel	4,800
Data Processing Staff	31,000
Shop Foremen	7,080
Other Field Support	9,900
Mechanics	5,780
Advisory Committee	3,440
Steering Committee	2,040
Total Direct Salaries	$ 91,800
Fringe Benefits	19,280
Total Personnel Costs	$ 111,080
Estimated Expenses	
Travel and Subsistence 120 days @ $38	$ 4,560
Vehicle Rentals 280 days @ $35	$ 9,800
Training Materials	1,500
Consultant Fees	120,000
Total Expenses	$ 135,860
Estimated Project Cost	$ 246,940

This alternative calls for development of a system using the Department's data processing staff to write the necessary computer programs. It also includes developing and conducting a limited amount of field training of equipment operators, and the use of an outside consultant for development and implementation assistance. (Variations to this basic alternative are described in some detail below).

- Alternative II-A - Using Programs from Another State

  This alternative calls for obtaining and modifying, as necessary, computer programs from another state that has developed an acceptable equipment management system. This would probably reduce the in-house program development costs by 20 percent to 40 percent, depending upon the adaptability of the programs selected. (A 30 percent reduction would cut the man day effort by 60 days and the total project cost by $11,250.) In this alternative, some report flexibility is lost and the specific information needs of the Department may not be entirely met.

- Alternative II-B - Exclude Mechanic Training

  Another alternative would be to exclude mechanic training as a specific requirement of the project. This option would reduce the original estimate by 105 man-days and the total project costs by $5,780. However, mechanic training was identified as an important need. This alternative should not be considered unless the responsibility for development of a training program is provided for by the Department through some other means.

- Alternative II-C - Develop and Implement Without Outside Consultant Assistance

  The basic alternative calls for 220 man days of consultant effort, at a cost of $120,000. If the Department decides to develop and implement an equipment management system entirely with in-house staff, a portion of the $120,000 can be saved. The original 220 man-days would have to be included in the Department man-day requirements, and would increase the in-house costs by about $21,800. So the net reduction in the project cost would be $98,200. At least, it appears that way. The fact is that consultant assistance will enable the Department to develop and implement a new system in about 14 months -- or less than half the time it is taking highway departments that do not

have the benefit of outside expertise. Recent contacts with several state highway departments indicate that system development and implementation time without a consultant ranges from three years (in Oregon and California) to four or five years (in New Mexico). [1] In effect, the savings of $98,200 in consultant fees is eliminated if a project takes at least twice as long, (without a consultant).

Consultants, incidentally, will generally provide full-time support during a system development stage, and part-time support during implementation. About 170 of the 220 man-days would be allocated to system development; 50 man-days would be allocated to ensuring effective implementation.

3. OTHER ALTERNATIVES

The project staff considered a number of other alternatives, such as these two:

- Concentrate Only on Refinements to the Information Sub-System

  This alternative would be relatively inexpensive. Total costs, including about $60,000 in consultant assistance, would amount to about $120,000. Unfortunately, the Department would still lack a "total funding" approach to equipment. Also, a number of the refinements recommended in the information system are closely tied to standardized maintenance practices. (Refinements in the information system would not be complete without refinements in the way shop foremen and others manage equipment maintenance.)

  In some respects, this alternative is comparable to a "commercial" system in which reports are generated, without assurances of appropriate management action or standardized practices.

- Retain a Management Analyst

  A trained management analyst could be retained for about $80,000 per year, (including administrative and committee support). The main job of the analyst would be to collect, analyze and summarize equipment management data. This alternative also would be relatively inexpensive, but it is doubtful that his work would result in improved management system. The main reason is that without a specific

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[1] By contract, the Colorado Department of Highways is mid-way through a 13-month project and the Arizona DOT is gearing up for a 15-month project -- both with consultant assistance.

commitment to making real improvements, people who function as an analyst almost always become involved in the day-to-day business (and problems) associated with current practices. Additional facts could be compiled to support the need for a better system, but chances are good that very little would be accomplished.

The benefits associated with either alternative would probably be less than the cost of the alternative.

V. RECOMMENDED COURSE OF ACTION

The User Steering Committee recommended that the Department develop and implement an equipment management system, outlined as Alternative II -- including development of computer programs on an in-house basis, and development and initial implementation of an operator training program, with consultant assistance in each area.

1. DEVELOPMENT AND IMPLEMENTATION TASKS

A number of specific tasks need to be carried out, to develop and implement an equipment management system. A work plan that outlines the necessary tasks, developed with the User Steering Committee, is summarized below, in two stages: system development and system implementation.

- Stage One - System Development

  1. Review and update the Organizational and Management Practices Report (this report), and redefine concepts, as necessary, regarding:

     a. Equipment funding;
     b. Information needs;
     c. Organization requirements; and
     d. Training requirements.

  2. Establish policy statements for top management approval, regarding:

     a. Equipment accounting and funding;
     b. Organizational responsibility for equipment maintenance and inventory support; and
     c. Systems and accounting relationships.

3. Revise, as necessary, the equipment enterprise fund, to achieve total funding of the equipment program:

   a. Establish all necessary accounts and controls; and
   b. Revise the rental rate structure.

4. Conduct a system orientation for field supervisors.

5. Develop initial training course materials for mechanic training.

6. Define information needs, including reports needed, report formats and frequencies.

7. Prepare computer design:

   a. Determine program requirements;
   b. Organize data base; and
   c. Determine on-line and batch processing requirements.

8. Develop computer input procedures and necessary source documents, fully integrated with accounting and SBAS requirements.

9. Develop computer program specifications.

10. Write, test and document computer programs.

11. Refine field shop and equipment operator procedures:

    a. PM and servicing procedures;
    b. Shop scheduling procedures; and
    c. Operator responsibilities.

12. Field test system procedures in one division.

13. Revise system procedures, based on the field test.

14. Develop systems training materials

15. Develop necessary manuals and system documentation.

    a. Systems manual; and
    b. Field operations manual.

- Stage Two - System Implementation

  16. Conduct training:

      a. Systems operations; and
      b. Mechanic training.

  17. Implement system procedures, state-wide.

  18. Conduct a follow-up review of the implementation, and monitor system operation.

- Other Work

  19. Organize and conduct regular advisory and steering committee meetings.

  20. Prepare monthly progress reports.

2. PROJECT SCHEDULE

A total of 14 months will be required to complete the recommended work plan -- nine months for Stage One - system design, and five months for Stage Two - system implementation. It is expected that the operator and mechanic training portions of the project will extend beyond this project schedule -- to to ensure that the training is effective and to meet all of the critical training needs.

3. SYSTEM BENEFITS

The implementation of the recommended equipment management system, along with the recommended organizational changes to support this system, will provide clear and tangible benefits. These benefits are summarized in the areas of need that the system was designed to address:

- Total Equipment Funding

  The benefits from adopting a total fund concept provides a stable equipment replacement cycle, based on the economic life of each unit -- rather than on the current status of the earmarked revenue account. Total equipment funding takes equipment replacement decisions out of a situation where equipment managers are competing each year for funds, and encourages replacement decisions that are based purely on equipment performance. The end result is an up-to-date fleet that can perform better, cost less and increase user productivity.

- Improved Information

  An improved management information system will result in better decisions regarding equipment performance, shop scheduling, PM compliance and the level of maintenance being performed on the fleet. The information system will reduce the need for manually keeping of separate records and reduce the excessive time (and cost) required to get data into, and information out of the system.

- Organization

  The minor organizational changes recommended in this report are designed to get better utilization of the existing staff, improve communications, (both from within the Equipment Division and with the fleet users), and provide better support to the Department.

- Increased Operator Awareness

  A training program now being designed to increase awareness of operator responsibility and proper use of equipment will result in reduced accidents and equipment abuse, increased life and availability of the equipment and reduced costs. Also, we would expect an increase in the morale and job satisfaction of equipment operators and shop mechanics, and most importantly, a safer operation.

The end result of improvements in all of these areas will show up immediately, and throughout future years, in reduced downtime, increased productivity, increased equipment utilization and life, and reduced

costs to operate, maintain and own the fleet. The benefits of an equipment management system is summarized effectively in a statement from the FHWA Manual - Equipment Management Systems - Part I (June 1978):

> "The greatest value in implementing an equipment management system is likely to lie in improved management control and service to equipment users. This control can result from improved management understanding of established operational goals, of the actions necessary to attain them, and in the measurement of their outcome. The benefits of improved management control include the ability to make the right decisions correctly, to support them, and to demonstrate positive results."

4. SYSTEM SAVINGS

By implementing the improvements recommended in this report, the Department can expect to realize actual cost savings -- both within the Division, and through the fleet users. The savings will occur in three key areas: increased productivity, reduced downtime, and reduced accidents and equipment abuse.

System experience from other agencies has shown an increase in performance (including reduced downtime) that reduces total equipment costs by 5% to 13%. This range of savings is supported by research conducted by the Federal Highway Administration (FHWA) in its report of June 1978. Equipment Management System - Part I. We expect that increased productivity will occur through better utilization of shop personnel, through proper planning and scheduling; better control of the stockrooms, to reduce parts handling and carrying costs; increased skill levels through mechanic training; and reduced time spent on repairs, due to standardized maintenance practices.

The Department will reduce downtime as a result of several elements of the system:

- Improved preventive maintenance;
- Standardized maintenance practices;
- Reduced age of the fleet through proper replacement;
- Reduced accidents and abuse; and
- Better information on equipment performance.

As indicated in the sample of equipment data summarized in Exhibit 5 (page 16), a substantial number of the units have exceeded their estimated life, and these older units are experiencing an average of 9.5 hours more downtime per unit for the 224 units in these four classes. The increased downtime would not occur if the fleet were replaced at the proper time. The 9.5 hours per unit over the 224 units in these four classes of equipment represent a total of 2,128 "lost" equipment hours per year. It is estimated that one hour of equipment downtime for these four classes of equipment represents a cost of $20 per hour to the Department. (This estimated cost includes the loss of crew productivity, equipment rental generated and work not performed. It excludes the far more costly situation where a key unit such as an asphalt distributor breaks down, causing 10 to 15 men and other equipment units to be idle for a period of time.) Again, just in these four classes of equipment, the dollar value saved by avoiding downtime is about $42,600. Since this sample represents 32% of the total fleet, the savings associated with reduced downtime would probably range from $100,000 to $130,000 per year.

Another area where reduced downtime will occur is through standard maintenance practices. As shown in Exhibit 6 (page 19) there is a wide range of downtime per unit between the various equipment maintenance shops. When standard maintenance practices are implemented, the maintenance shops experiencing high downtime per unit should fall within an acceptable range. Shown below is an estimate of the impacts of reduced downtime through an effort to bring all shops within an acceptable range, (one standard deviation above the statewide mean):

Class	Equipment Hours Per Year Saved	Cost Per Hour		Total Saved
Dump Truck	1,012	$26		$26,300
Motor Patrol	274	20		5,500
Loader	374	17		6,400
Pickup	570	15		8,600
			Total	$46,800

Again, since these four classes represent only 32% of the fleet, the total savings would be in the range of $120,000 to $145,000.

These cost savings alone, projected out over the next five years, far exceed the initial project cost of $246,940.

Also, as mentioned in the Summary of Findings, the Department has spent approximately $19,000 this past year on repairs directly resulting from accidents and abuse. This represents an annual cost to the Department that would be significantly reduced through proper training and increased operator responsibility. A conservative estimate would be $10,000 per year in savings, (not directly attributable to the new system).

In addition to the savings associated with reduced downtime, we expect productivity increases (noted on page 48) to result in an annual savings of at least 6 percent of the cost of maintenance labor. Six percent of the current labor cost (roughly $2,480,700 statewide) is $148,850. And, given annual labor cost increases of 10 percent, the total savings through productivity increases amounts to $900,000.

A summary of the total savings amounts to about $1.9 million:

	Years After Implementation						
Cost/Savings ($1,000)	0	1	2	3	4	5	Total
Project Cost	$247						
Downtime Savings							
Reduced Fleet Age		60	80	80	100	100	420
Improved Maintenance		100	120	120	120	120	580
Increased Productivity		149	164	180	197	210	900
Total	$247	309	364	380	417	430	1,900

Notice that the savings values represent minimum estimated savings. The average annual savings -- $380,000 -- represents about 5 percent of the Department's current budget of nearly $7.5 million. At this rate, the investment in the project is recovered during the first year of system operation, and provides a five-year benefit of over eight times the project cost.

R.J. HANSEN ASSOCIATES, INC.

MANAGEMENT AND INFORMATION SYSTEMS CONSULTANTS

CONSTRUCTION

MANAGEMENT INFORMATION NEEDS ANALYSIS

FOR THE

DEPARTMENT OF HIGHWAY
STATE OF MONTANA

July 1981

Final Draft

FINAL REPORT

EVALUATION AND RECOMMENDATIONS of the CONSTRUCTION FUNCTION

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

July 1981

Prepared by

Bergstralh Associates, Inc.
under subcontract to
R. J. Hansen Associates

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I. INTRODUCTION

BACKGROUND AND OBJECTIVES

The major objective of the Construction Bureau is to construct highways and bridges of high quality in a cost effective manner. The function is carried out by the Bureau Chief, central office staff, division construction section supervisors and staff, field project managers and project staffs. The Materials Bureau assists the Construction Bureau by providing basic services in testing, inspection and approval of materials to be incorporated into the construction projects.

The construction function includes administration of contracts, quality assurance, enforcement of specifications, staking and documentation.

In addition to administering the construction program, the division construction supervisors and their staffs are responsible for completing the preliminary surveys for project design. Where photogrammetry is used, they provide ground control and supplemental survey data. All other preliminary surveys are completed entirely in the field.

This report covers an evaluation of current practices, a conceptual framework for improved systems and procedures and the basic information needs and organizational structure to effect the improvements for the Construction Bureau.

SUMMARY OF RECOMMENDATIONS

The construction workload in Montana varies considerably from year to year and between division construction sections, and it is quite seasonal. These conditions make manpower planning difficult. Supervisors need all the management tools possible.

Twenty-one states and the FHWA sponsored development of a "Pooled Fund" model construction engineering manpower management system that is readily adapted to meet the needs of individual states.

It is recommended that the Department adapt that system to fit conditions and requirements in Montana. The system includes elements for:

- planning,
- staffing,
- budgeting,
- scheduling,
- monitoring,
- system updating, and
- improving work methods.

The use of this model will expedite system development and implementation so that benefits can be realized as soon as possible.

Work methods and procedures used by the Department should be reviewed periodically to ensure that they are cost effective. The Work Methods Improvement procedure provides guidelines for setting up a Work Methods Improvement Committee to conduct evaluations and make recommendations for implementation of improvements.

It is recommended that a Work Methods Improvement Committee be established to identify and evaluate work methods for improvement.

Personnel classification plans should support effective management of manpower. Promotions in the field should be based on proven ability to effectively perform a variety of construction and preliminary survey assignments. Because of the variability in the workload versatility is essential.

It is recommended that the current personnel classification plan be evaluated to ensure that it does support manpower management. If it does, no changes will be needed. If it does not, the plan, including position descriptions and promotional criteria, should be revised.

The Steering Committee for Construction identified a need for additional training to develop more versatile employees for better utilization of manpower as well as to improve the uniformity of inspection. No specific subject areas for training were identified.

It is recommended that an analysis of training needs be conducted to determine the critical training needs in construction and that a training program be designed to meet any needs identified.

Experience in other states indicates that construction engineering costs will be reduced through implementation of these recommendations. The potential annual savings in construction engineering costs for one year will more than pay the development and implementation costs while the savings will continue year after year.

II. SUMMARY OF FINDINGS

The current organization, responsibilities, and practices for administering the Department's construction program were identified through interviews, Steering Committee meetings and reviews of manuals and reports. The findings are summarized in this section. The organization and responsibilities are presented first, followed by an analysis of reported data, an overview of existing management systems and management information needs. A listing of identified problems concludes this section of the report.

CURRENT ORGANIZATION AND RESPONSIBILITIES

The organization for the construction function is documented in the figures on the following pages. Figure 1 shows the Department organizational relationship to the Construction Bureau. The organization of the Construction Bureau is shown in Figure 2. The organization of a typical division construction section is shown in Figure 3.

An explanation of the responsibilities of each level of management in administering the construction program is summarized from the Construction Manual. Only the construction responsibilities are emphasized in this report, although most have responsibilities in a number of other areas.

In addition to these construction responsibilities, division construction section personnel and the Materials Bureau are responsible for portions of the preconstruction work program.

Figure 1

DEPARTMENT ORGANIZATION RELATED TO CONSTRUCTION

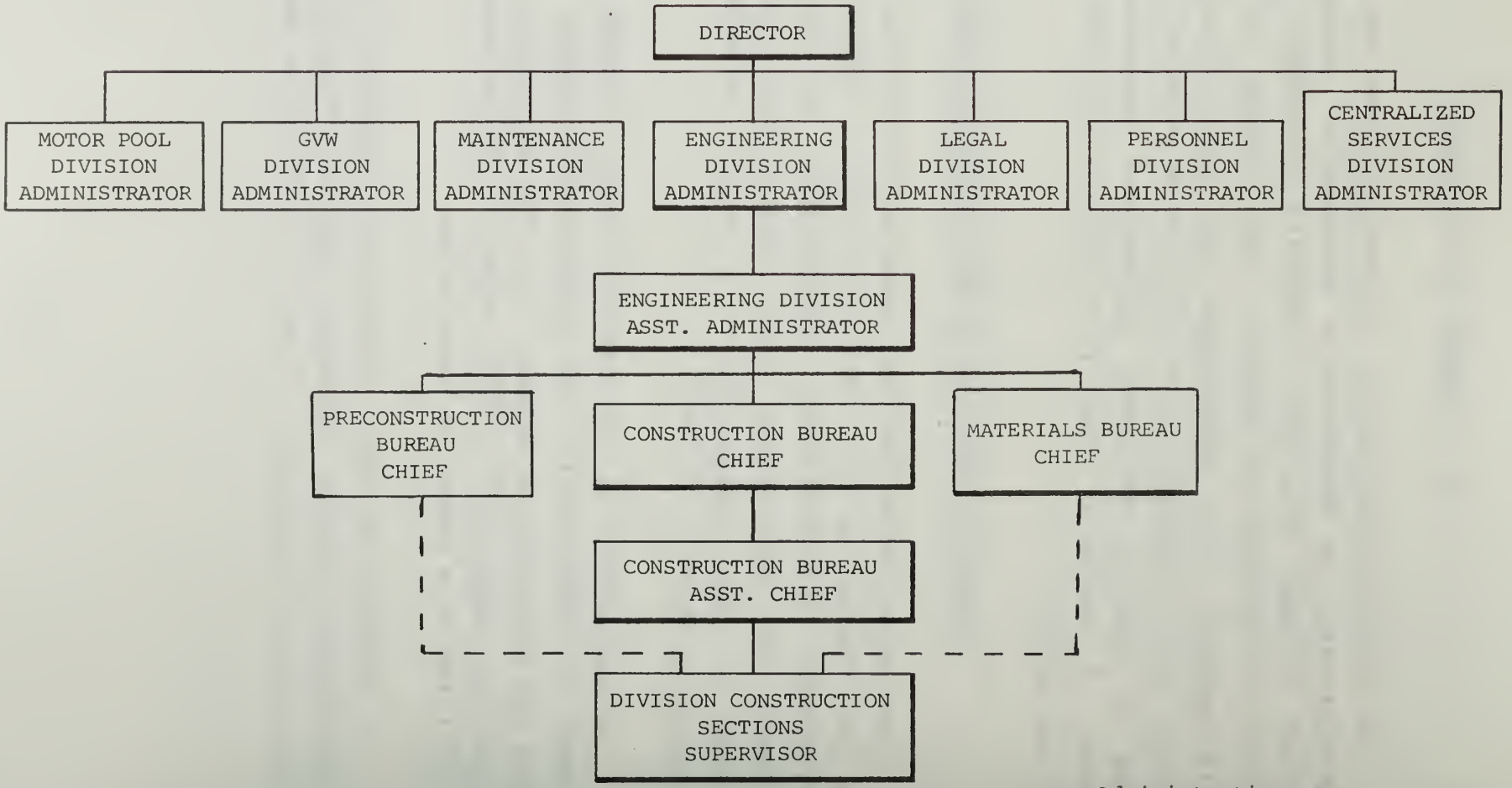


Figure 2

CONSTRUCTION BUREAU ORGANIZATION

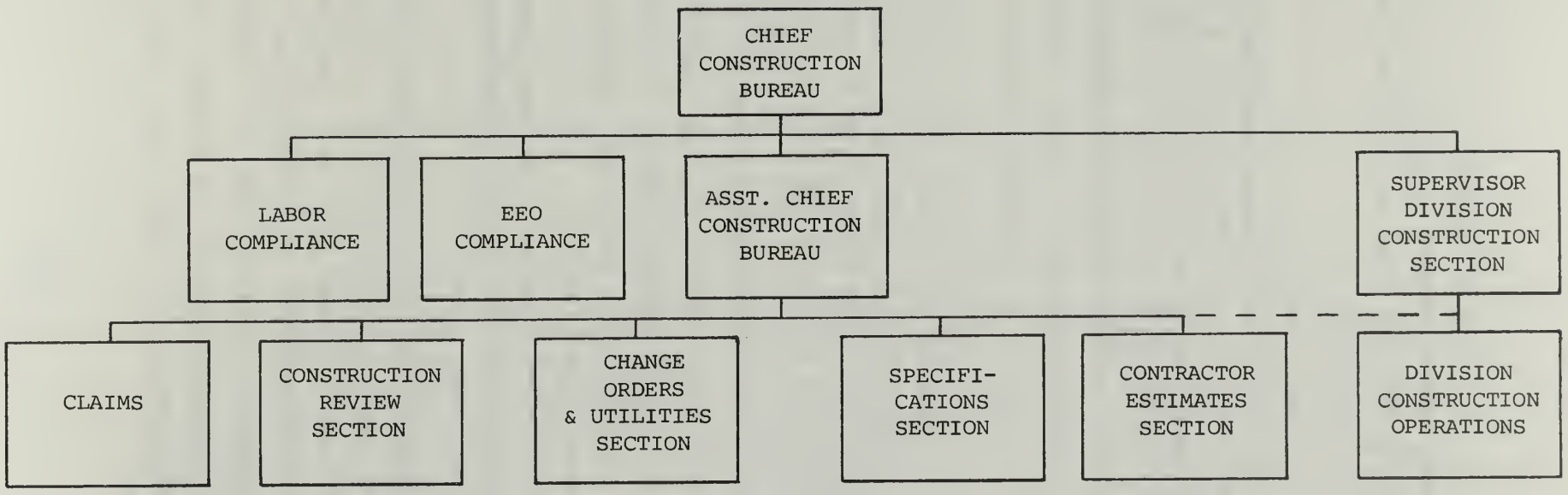
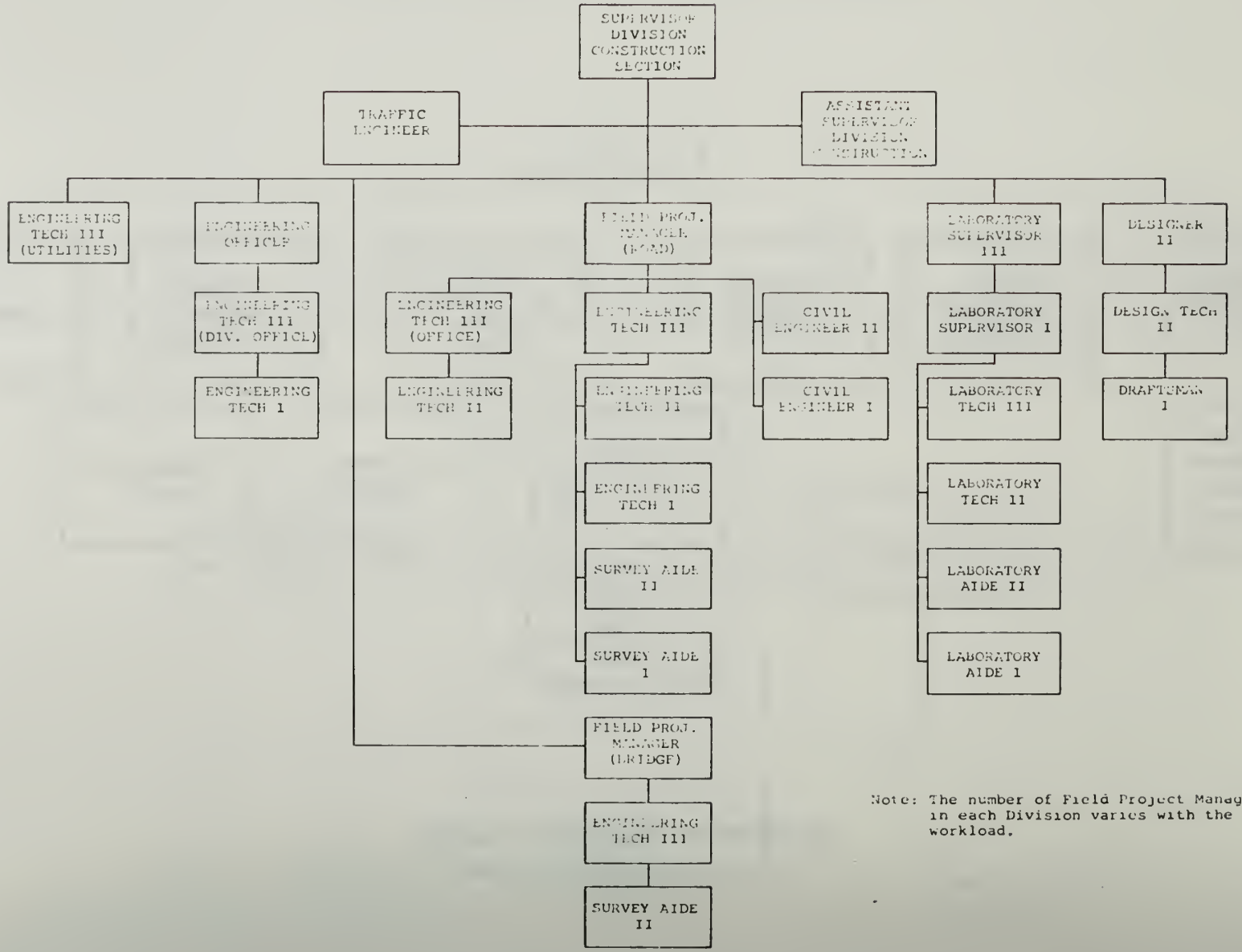


Figure 3

TYPICAL DIVISION CONSTRUCTION SECTION OPERATIONS



Note: The number of Field Project Managers in each Division varies with the workload.

Responsibilities

The Director of Highways is responsible for administration of the construction function as well as all other operations of the Department.

The Administrator of the Engineering Division directs and coordinates the Preconstruction, Construction, and Materials Bureaus. In matters related to Construction, he is responsible for administering the total construction program and coordinating construction programs with other highway administrative offices. He performs liaison with the Federal Highway Administration and other Federal or State Agencies.

The Construction Bureau Chief, with the Bureau staff, assists the Division Construction Section Supervisors in providing supervision and control of all construction projects to assure quality construction, conformance to contract requirements and to resolve construction problems.

The Bureau Chief is authorized to take appropriate action on contract changes, time extensions, liquidated damages, contractors' claims, progress and final estimates, Federal Highway Administration inspection recommendations, labor compliance matters and other construction activities delegated to him by the Engineering Division Administrator.

The Division Construction Section Supervisor is the authorized representative of the Construction Bureau Chief in all construction matters for the geographical area to which he is assigned. He coordinates the preconstruction, construction and materials functions in the division construction section. He accomplishes all phases of this assignment with the help of his staff but is free to call on headquarters specialists for

assistance in solving the more unusual or complicated problems he encounters. His responsibilities and duties include scheduling construction surveys, coordinating personnel assignments, providing for inspection of materials and workmanship, assuring that plans and specifications are being complied with and arranging other activities of contract administration.

The Division Office Engineer performs various construction functions such as thoroughly checking final estimates and supporting data, reviewing contract changes, supervising design crews, presenting testimony at condemnation hearings, reviewing field changes and drainage problems, conducting or attending preconstruction conferences and performing overall liaison between the Division Construction Section Office and project functions.

The Division Materials Supervisor is under the direct supervision of the Division Construction Section Supervisor but receives technical guidance and direction from the Materials Bureau Chief. Personnel working in the Division Materials Section are responsible for training construction personnel in testing, sampling, and inspection methods as well as performing the testing and inspection functions assigned to them.

The Project Manager is responsible for the supervision and coordination of engineering, inspection and documentation activities on assigned road or bridge contracts; coordinates the construction activities of prime and sub contractors, public utility companies, and other governmental agencies; and represents the Department in contacts with the public, local governmental agencies, representatives of public utility companies, and others directly concerned with construction activities on the projects.

Engineer Technicians III, under the direction of the Project Manager, supervise various engineer technicians and survey aides assigned to inspection, staking and office functions and personally handle the more critical inspection duties. They may be placed in responsible charge of projects under the direction of the Division Construction Supervisor.

Other Engineer Technicians and Survey Aides perform surveys, inspect and document construction, and materials tests.

WORKLOAD AND STAFFING

The construction workload has fluctuated considerably in recent years. There are a number of reasons for the fluctuations -- all outside the control of the Contruction Bureau. Construction must staff the projects actually awarded and field surveys for preconstruction. Little consideration in scheduling projects for award is given to the availability of personnel in the Division Construction Sections to staff projects.

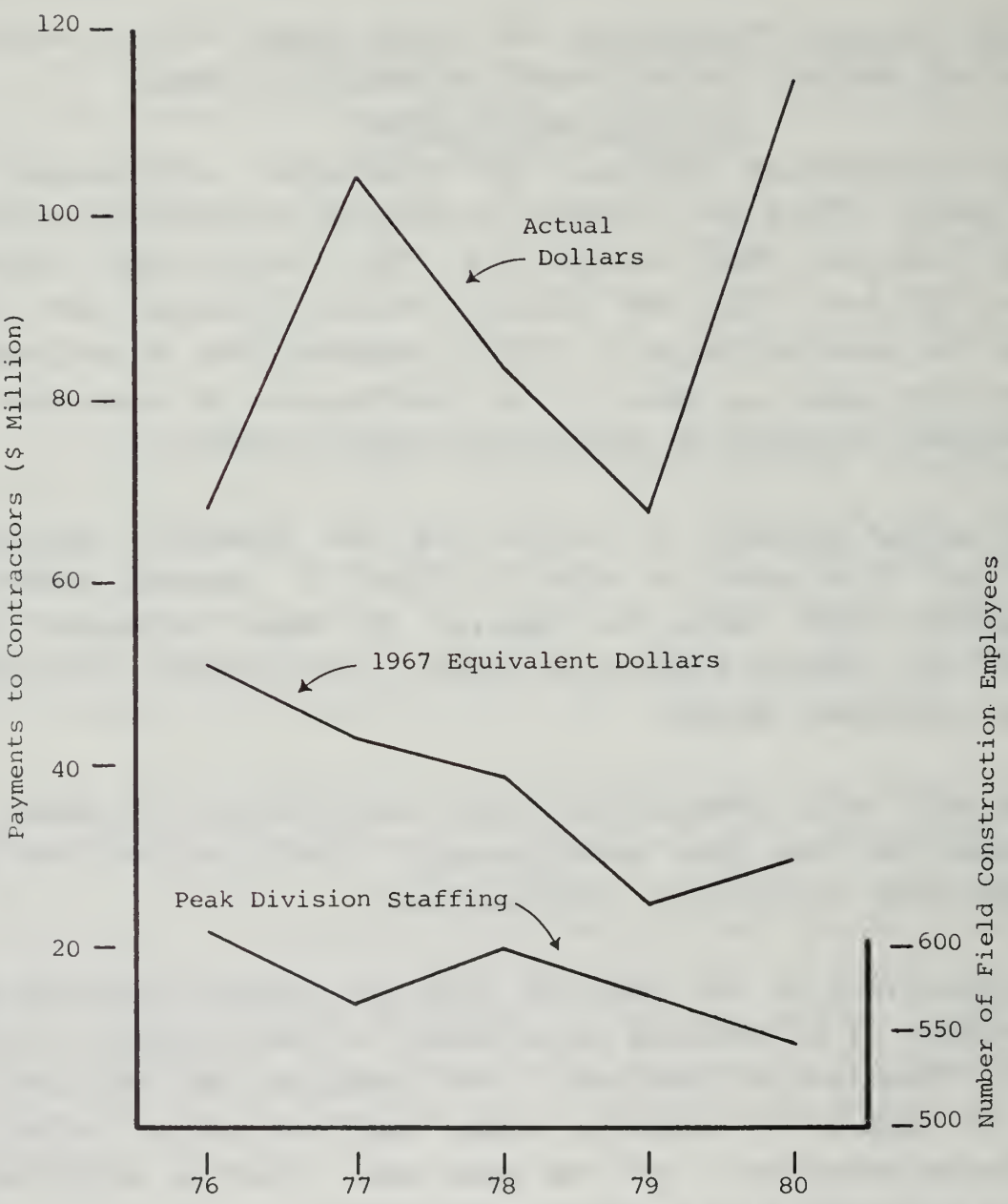
The actual payments to contractors have generally increased in the last five years as shown in Figure 4. However, when the construction cost index is applied to take inflation into account, the effective workload trend is downward by 22 percent over the five-year period.

The peak field construction staff has gradually decreased by 10 percent in the same time period. This does include the decreases made recently by the Department.

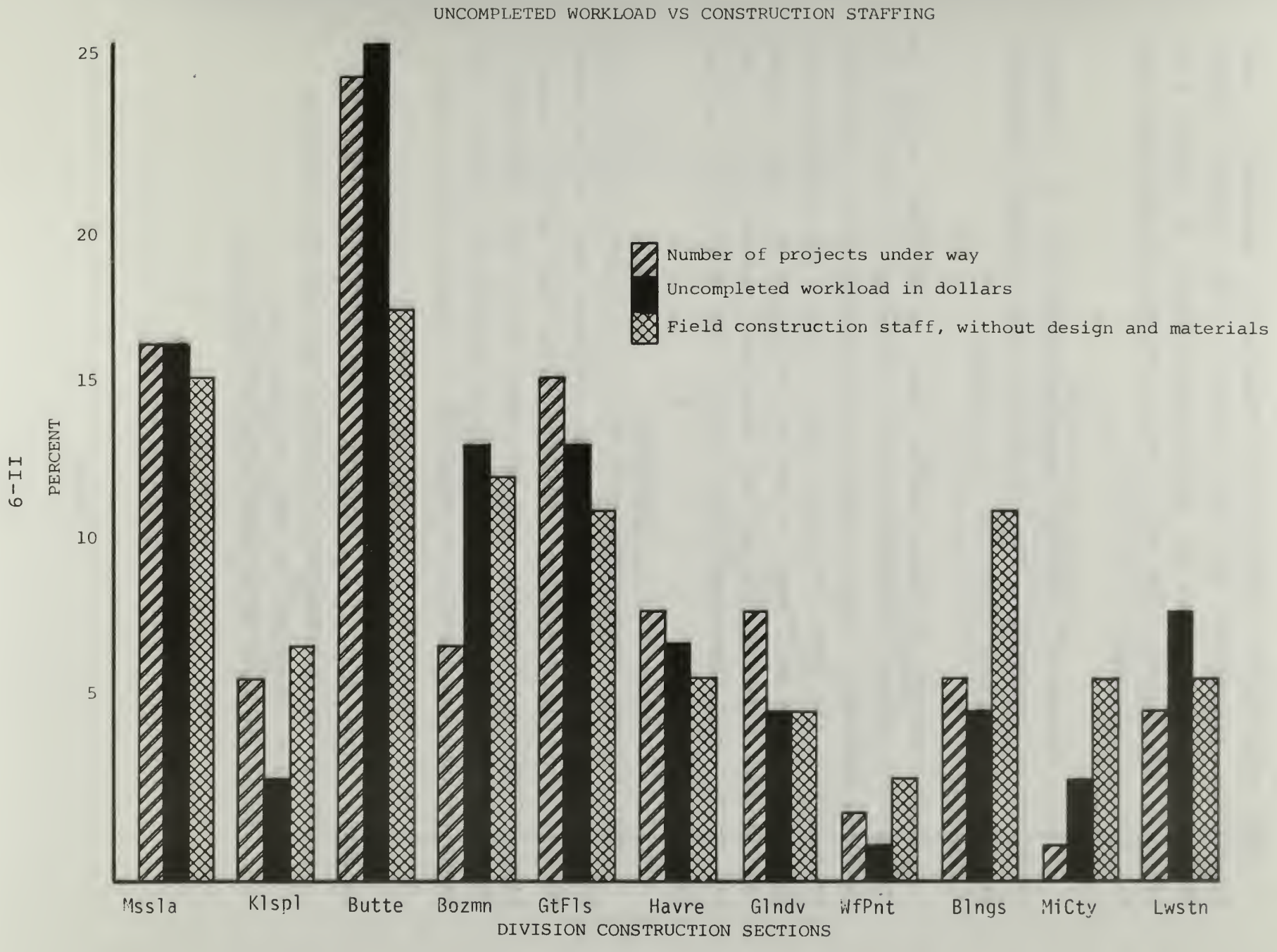
A comparison of the staffing with the current workload was made (Figure 5) to identify gross under- or over-staffing in the Division Construction Sections. The workload was measured in terms of number of projects under way and dollar value of uncompleted contracts. For the most part, staffing percentages compared favorably with workload percentages.

Figure 4

WORKLOAD VS STAFFING



6-II


UNCOMPLETED WORKLOAD VS CONSTRUCTION STAFFING
PERCENT
25
20
15
10
5
Number of projects under way
Uncompleted workload in dollars
Field construction staff, without design and materials
Mssla
Klspl
Butte
Bozmn
GtFls
Havre
Glndv
WfPnt
Blngs
MiCty
Lwstn
DIVISION CONSTRUCTION SECTIONS

The construction workload in Montana is seasonal. Most contractor operations are shut down in the winter months. Payments to contractors by month were plotted in Figure 6 to identify the trends. The major amount of work is performed from May through November.

This imbalance presents special problems in staffing construction projects. The Department uses seasonal employees and overtime to help alleviate the problem.

Study results in other states have shown that thirty to thirty-five percent of construction engineering can be done by seasonal employees. While Montana has averaged 26 to 35 percent seasonals in the last five years, some division construction sections have used well over 35 percent seasonals at times (Figure 7). A good training program for seasonals is essential if they are to be used effectively and maintain the quality of inspection.

Overtime

Most highway contractors work more than eight hours per day and many work six days per week to complete work in the short Montana construction season. The Department must provide inspection services to coincide with the hours set by the contractors. There is more flexibility in performing staking and office functions so they can usually be completed in regular working hours.

There are three alternatives for staffing the inspection function. They are:

- assign extra inspectors to reduce the need for overtime,
- require inspectors to work overtime, or
- allow the work to be done without inspection.

Figure 6

CONSTRUCTION WORKLOAD SEASONALITY

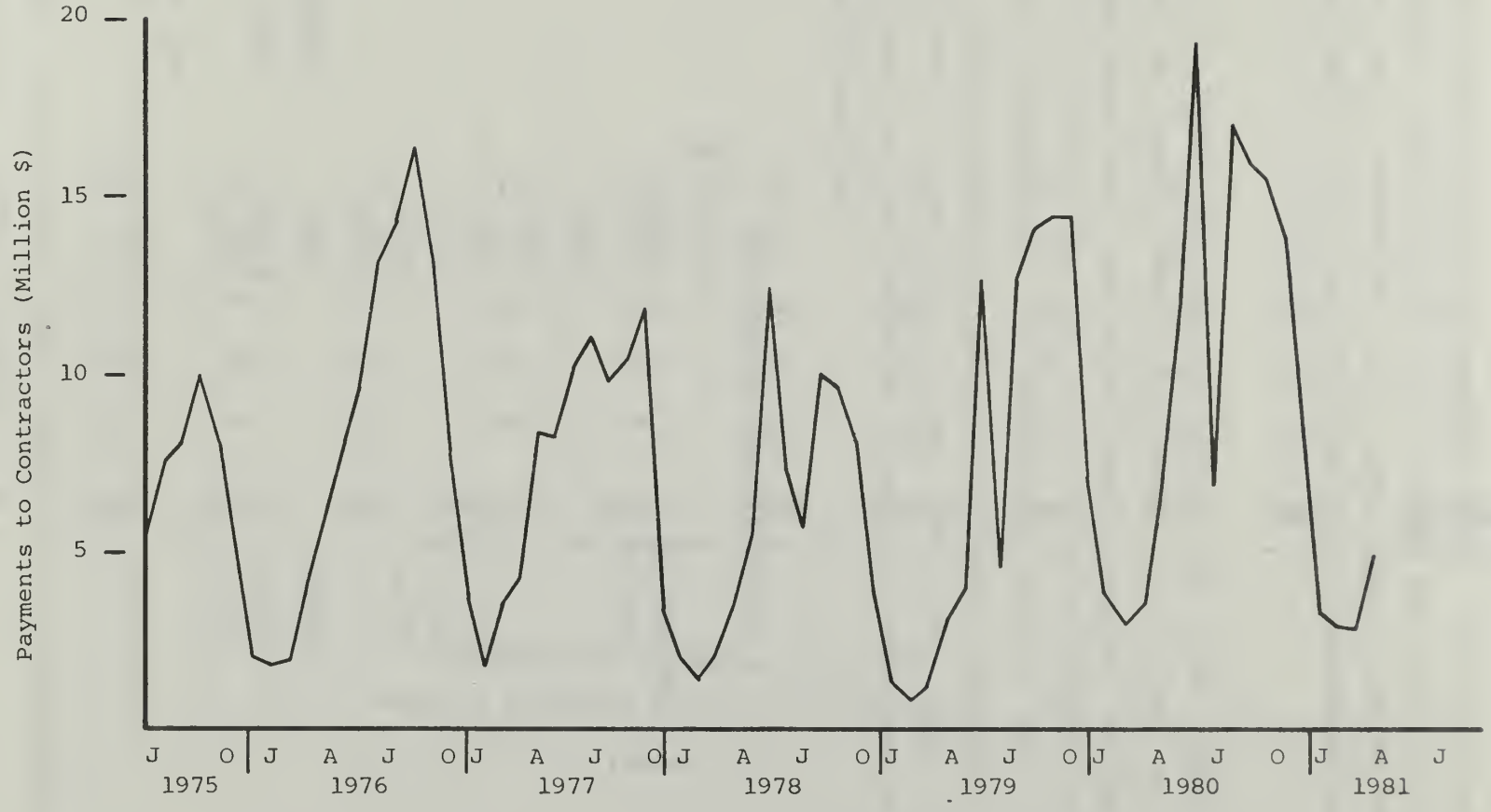


Figure 7

RATIO OF PERMANENT TO SEASONAL EMPLOYEES

SEASONALS AS A PERCENT OF TOTALS

Year	Division Construction Section											Statewide Average
	Miss	Kal	Butte	Boze	Gr.Falls	Havre	Glen	Wolf Pt.	Bill	M.C.	Lewis	
1976	36	32	26	33	50	36	44	21	36	25	39	35
1977	30	21	28	15	39	38	25	19	28	25	27	28
1978	39	22	40	35	35	24	6	45	31	10	23	32
1979	40	19	27	46	19	22	21	19	43	30	27	32
1980	41	13	17	47	15	13	20	11	19	19	23	26

Clearly, the last alternative is unacceptable. The first one is quite costly unless the contractor is running two shifts per day. For example, two inspectors with overlapping shifts to cover a twelve-hour shift will have four hours of non-productive time between them.

The Department is using overtime to reduce the total number of employees needed to handle peak workloads. In fiscal year 1980, overtime costs were less than 6% of regular wages. It may be cost effective to increase the use of overtime to reduce the number of permanent employees. It certainly should not be reduced further. While employees receive 50% more wages for overtime work, the cost to the State is only 27% more. Many of the fringe benefit costs do not increase because of overtime, as shown in the following analysis.

	Percent of Wages Earned	
Cost Item	Regular Time	Overtime
Salaries	1.0000	1.5000
Sick Leave	.0426	--
Vacation	.0638	--
Holidays	.0426	--
F.I.C.A.	.0613	.0920
Retirement	.0620	.0930
Group Insurance	.0543	--
Workers Comp. Insurance	.0056	.0084
State Unemployment Ins.	.0112	.0168
Total	1.3434	1.7102
Percent of Cost for Regular Time	100%	127%

If the allowance for commuting were included, the comparable cost of overtime would be further reduced.

Construction Engineering Costs

Construction engineering costs are primarily labor costs. Salaries and fringe benefits account for about 85 percent of the charges. Other charges include the Materials Bureau and equipment rental.

C.E. costs trends are shown in Figure 8. Costs have been over 10 percent of contractor's earnings in all but two of the last eight years.

C.E. costs were tabulated by division construction section for the last four years (Figure 9). Average C.E. costs vary considerably between division construction sections. The size, type and mix of projects assigned, the distance between projects and the contractor's progress will, of course, affect engineering costs. However, it is the opinion of the Consultant that the statewide average for construction engineering costs should not exceed 10 percent.

CURRENT MANAGEMENT SYSTEMS

Most construction manpower management systems include these elements:

- Planning and Staffing,
- Scheduling,
- Budgeting, and
- Monitoring.

The Department's methods of accomplishing the objectives of these work elements are discussed in the following pages.

Figure 8

CONSTRUCTION ENGINEERING COST TRENDS
AS A PERCENT OF PAYMENTS TO CONTRACTORS

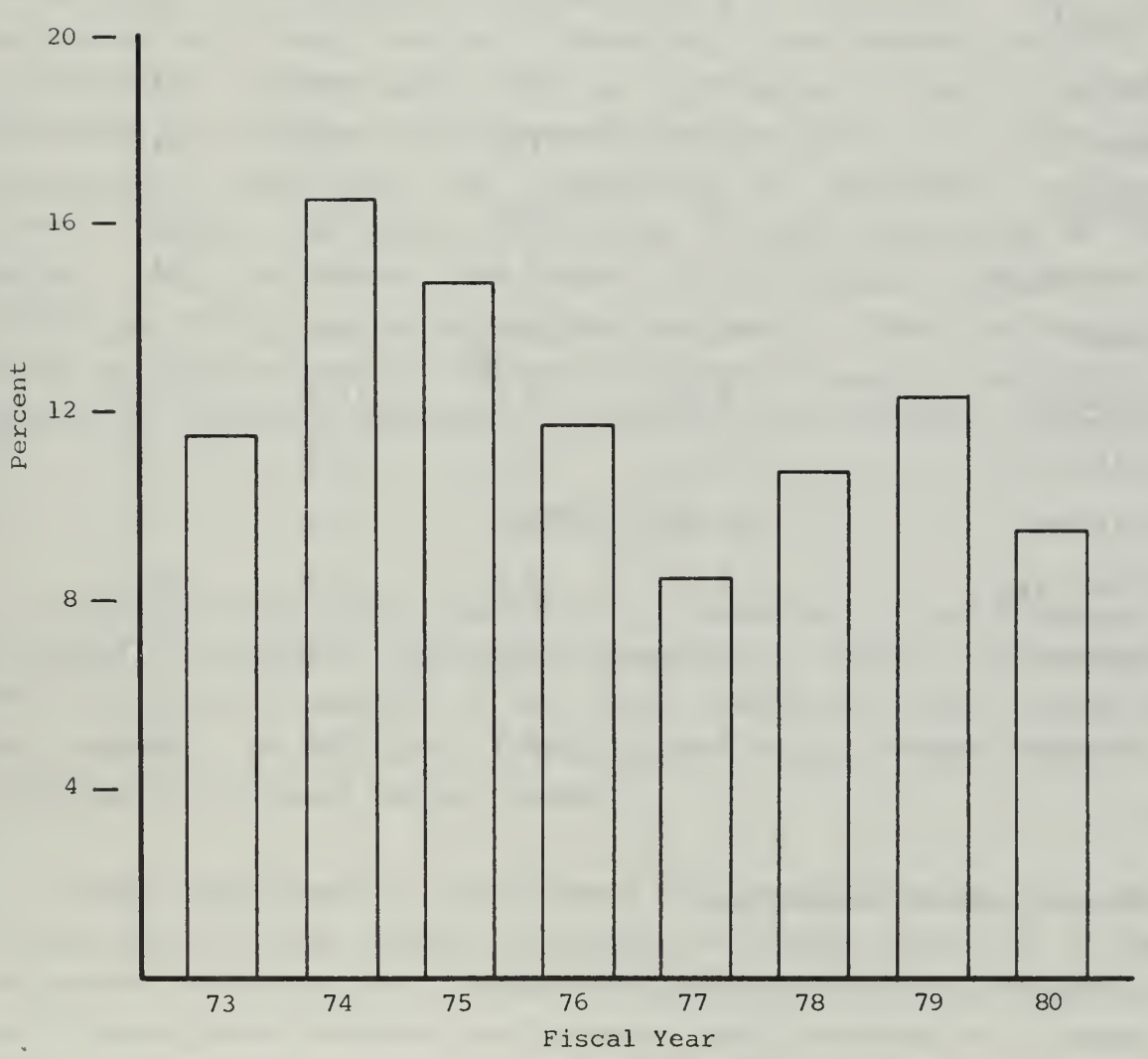


Figure 9

DIVISION CONSTRUCTION ENGINEERING COSTS
AS A PERCENT OF CONTRACTOR PAYMENTS

Division Construction Section	Fiscal Year 1977	1978	1979	1980
	- - - - - - - - Percents - - - - - - - -			
Missoula	7.2	11.1	10.3	8.3
Kalispell	9.1	3.9	12.4	11.5
Butte	10.1	11.7	12.5	11.3
Bozeman	9.2	10.8	18.1	11.2
Great Falls	7.7	9.1	9.9	11.1
Havre	9.9	10.9	16.8	7.4
Glendive	6.9	10.6	11.4	7.8
Wolf Point	9.5	9.3	10.8	8.4
Billings	10.2	13.5	14.3	7.7
Miles City	6.9	13.9	15.0	15.9
Lewistown	9.7	13.2	14.2	10.9
Statewide Average	8.6	10.9	12.4	9.5

Source: Special computer run.

Planning and Staffing

Planning and staffing involves estimating manpower needs to staff the work program over the coming year or years.

The Department does not have a formal documented manpower planning and staffing procedure. However, most Division Construction Section supervisors make an estimate of staffing needs once or twice a year -- usually in the spring before construction work begins and sometimes in the fall. When these estimates are made, projects under way, anticipated projects and preliminary surveys must all be considered. Each project is reviewed to consider the expected starting date, the contractor's anticipated progress, the capability of available employees, local weather and soils conditions and the proximity of other work. All estimates are based on individual judgment. No staffing guidelines or standards are used. These estimates are used to make permanent employee assignments and to determine the needs for seasonal employees and additional permanent employees.

Scheduling

Because of the many variables in construction of highways and bridges -- weather, equipment breakdowns, delays for materials and the like -- manpower plans, while necessary, will seldom work out exactly as planned. Scheduling covers these short-term assignments to meet actual needs.

Field construction supervisors are accomplishing many of the objectives of this element although no formal procedure is used. Personnel are generally assigned to specific Project Managers but are transferred between assignments and projects on a week-to-week or day-to-day basis to balance manpower with the workload.

Insofar as possible, key personnel are kept on the same project until completion to provide continuity in inspection, documentation and staking operations. Personnel are also transferred between Divisions to balance staffing with workloads.

Secondary assignments are made to utilize time that might otherwise be wasted during periods when the contractor is not working. Preliminary survey activities are usually used as secondary assignments but survey notes reduction, other office work and making final field measurements are also frequently used. Bridge maintenance inspections also are conducted during slack time when qualified personnel are available.

Budgeting

A budget is needed to estimate the costs of administering the construction program. The procedure now in use by the Bureau is outlined below.

Each Division Construction Section Supervisor prepares a detailed budget based on the estimated needs for staffing current projects and surveys and those anticpated to begin during the budget year. The level of detail conforms with that required for approval by the Legislature and involves about 150 line items.

Each Division Construction Section prepares its budget in its own format. Staffing estimates for each project are developed based on judgment and past practices. Current individual salaries plus any anticipated increases are used to price out the staffing needs. Similarly, an estimate is made for all appropriate line items. The process is quite detailed and time consuming. No standards are used. The use of standards could reduce preparation time and ensure more uniform estimates.

Division construction section budgets are submitted to the Construction Bureau where they are reviewed, revised in some cases, and then combined with the Bureau budget. The total budget is then submitted to top management for approval.

Monitoring

Monitoring involves comparing actual results with the planned staffing and budgeting.

The major report available for monitoring project management is the construction engineering cost report. This report is of little value to Project Managers and Division Construction Section Supervisors for the following reasons:

- Costs are not separated by responsibility. For example, the report does not isolate costs generated by Project Managers from those over which they have no control such as materials testing in the divisions or central Materials Bureau.

- Construction engineering costs for combined projects on the report are not shown correctly. Additional calculations are required to determine the C.E. cost percentage.

- Turnaround time is slow. The report is at least a month old when it is received in the field.

A second report summarizes the overtime worked by each employee for each project. It is used to monitor the use of overtime.

In addition to these reports, the Chief of the Construction Bureau receives or compiles the following reports:

- The Field Enginering and Construction Progress Report summarizes the status of all construction projects under contract and preconstruction assigned to the field.

- The monthly financial report shows the budget, expenditures and balance remaining for each division construction section and the Bureau.

- A report is compiled to summarize the payments for commuter allowances and secondary quarters.

- A monthly construction report is compiled to show data for each active project, such as the contract amount, payments to date, uncompleted balance, contract dates and percent work is complete.

MANAGEMENT INFORMATION NEEDS

Each management level has a unique need for management information. The following information needs were identified.

Field Project Manager

Planning and Staffing
- Staffing guidelines
- Contractors' schedules

Monitoring
- Construction engineering costs for assigned projects.

Division Construction Section Supervisor

Planning, Staffing and Budgeting:

- Realistic construction program schedule including contract award dates.

- Milestone dates for starting and completing preconstruction activities such as preliminary surveys, utility relocations and R/W staking.

Monitoring:

- Construction engineering costs.
- Budget comparisons -- actual expenditures versus planned.

PROBLEMS IDENTIFIED

In the course of this study, a number of problems that affect the construction operation were identified. Time did not permit detailed analyses to confirm the problems or develop potential solutions. The Steering Committee members did not all concur with every problem listed. Some of these problems are minor but were included to inform management of them. They are listed here for possible future study by the Department.

The problems can be separated into two categories:

- technical, and
- personnel management.

TECHNICAL

- Need to provide more training for Department personnel so they can replace the experienced personnel who have retired and to improve the uniformity of inspection throughout the state.

- The Department conducts very little research. An effort is made to keep up with research done by other states but those results may not be applicable in Montana. There is a need to evaluate successful as well as failed construction designs and procedures to determine causes and communicate them to design and construction supervisors.

- The Department tests some new materials or technology on experimental projects. This procedure is not as effective as it should be. Field personnel have the responsibility for administering the projects, analyzing the results, and writing the reports. They may not have the time or expertise to prepare good reports. The results from experimental projects are not always communicated throughout the Department.

- There is a concern that Department personnel are not keeping up with the state of the art in highway technology. (Increased participation of Department engineers in AASHTO and TRB meetings should be considered.)

- The cost of enforcing labor compliance is excessive and seems to require more time each year. It is distracting Project Managers and inspectors from monitoring construction quality. The costs versus benefits of the current procedure should be reviewed along with the trends in the

number of violations. It should also be determined if these violations were found through Department procedures or another way.

- Documentation of final quantities is very time consuming. The project crews prepare and check all final calculations and documentation. The Division Office Engineer then checks all calculations and documentations and forwards the final to the Construction Bureau in Helena. The Contractor's Estimate Section spot-checks calculations and documentation. This procedure provides three checks.

  The Project Manager should be responsible for the accuracy of final documentation. The Division and Bureau offices should spot check on a random sample basis. If an excessive number of errors are found through spot checking, the final should be returned to the Project Manger. Guidelines for accuracy of computations should be developed so all checkers are using the same criteria.

  The entire procedure for submission of final estimates should be reviewed to ensure that it meets current needs of the Department. For example, an explanation is required if a bid item underruns or overruns by 3% or $500, whichever is less. Because of inflation, it would now require over $1,000 to purchase items worth $500 in 1975.

- Documentation requirements should be reviewed to ensure that they are cost effective. Methods of measurement can often be simplified to reduce manpower requirements. Such techniques as paying plan quantities plus or minus changes, making minor items subsidiary and using standard

quantities for routine items help to simplify final calculations.

Personnel Management

- Hiring new personnel takes too long. All new hires must be from an approved applicant list provided by Helena. Addresses on this list are often no longer current and the better applicants usually have taken other jobs. (The policy of hiring through the State Employment Service should alleviate this problem when it is implemented statewide.)

- The better construction technicians can perform a variety of inspection, survey and office activities. If all permanent technicians had this versatility -- and were paid accordingly -- fewer permanent employees would be needed. Seasonals can perform the lower skilled assignments. Total salary costs would be lower although individual salaries would be higher.

- All criteria for promotion should be reviewed periodically to ensure that current needs are met. There is a need to improve criteria for evaluating employees for promotion to ensure that criteria are work related. Criteria should be clear so both employees and supervisors can uniformly interpret them. (The Department is in the process of implementing a performance appraisal system.)

- There is a need for off-season work assignments for field crews. Preliminary surveys and final computations are used as secondary assignments. The Department is con-

sidering increasing the use of photogrammetry for completing surveys. Since surveys are used for off-season work assignments, other work assignments must be found to replace them to utilize available manpower.

Eight of the eleven Division offices have design capabilities. More use of field employees to assist with designs should be considered to utilize off-season slack time.

- All overtime must be authorized by the Division Construction Section Supervisor. Project Managers should be authorized to approve overtime. Control of overtime can be maintained by monitoring the overtime used.

- Authorization of expenses for all construction technicians must be approved by the Construction Bureau Chief in accordance with the union agreement. The current policy provides for different expense rates depending upon the distance between the assigned office and the project site. Effective utilization of manpower requires flexibility in assigning individuals to projects on a week-to-week basis. Requests for approval of expenses may be continually in progress.

  Approval should be delegated to the division construction section supervisors.

III. RECOMMENDATIONS FOR CONSTRUCTION MANAGEMENT IMPROVEMENTS

The recommendations for improvements in managing construction and related organizational considerations are presented in this section.

RECOMMENDED SYSTEM

The construction workload, as measured in 1967 dollars, has decreased twenty-two percent in the last five years. The peak field construction staff decreased ten percent during the same time period. These two trends cannot be expected to exactly coincide because the typical type of construction and the average size of project have changed in the last few years. However, without staffing guidelines or standards, it is not possible to uniformly determine optimum staffing required to ensure quality construction without overstaffing.

Through the use of a formal construction management system, the optimum number and mix of employees to staff any particular workload can readily be estimated. Uniformity of staffing similar projects between division construction sections would be improved.

In Montana, as elsewhere, labor and related costs account for 85 percent of construction engineering costs. It is therefore logical to use the staffing requirements determined from the workload and staffing standards as a base for developing budgets -- performance based budgets.

Recommendation:

> It is recommended that Montana develop a Construction Manpower Management System by adapting the "Pooled Fund" System to meet the Department's needs.

The "Pooled Fund" Construction Engineering Manpower Management System was developed through the sponsorship of twenty-one states and the Federal Highway Administration. The System was designed to be tailored to meet the needs unique to each department. The System is based on data collected from a number of states that had developed management systems or staffing guidelines.

By taking advantage of this system, the Department can quickly develop its own unique system to fit actual conditions in Montana. The "Pooled Fund" System includes elements for:

- Planning and Staffing,
- Budgeting,
- Scheduling,
- Monitoring,
- System Updating, and
- Work Methods Improvements.

Alternative methods are provided in the System for some of the suggested procedures. The procedures for each element should be reviewed, alternatives selected, and modifications made to develop the best system for Montana. Management information needs are identified in the early steps. The system is then adapted to meet those needs. Major elements and possible modifications are described briefly below.

Planning and Staffing

The Planning element provides for grouping projects by similarity of staffing needs rather than by source of funding or other traditional methods. Planning standards are used to relate the engineering work to be done to the contract quantities. Modifiers are used to take conditions that affect productivity into account -- mountainous terrain, construction under traffic, or urban areas. Additional modifiers can be added for such conditions as isolated projects where alternate assignments are more difficult to schedule. The use of staffing standards and modifiers ensures uniformity in estimating staffing needs between projects and division construction sections. A typical set of base and modifier man-hour standards for reconstruction projects from the system Design Manual is shown in Figure 10. the activities, planning units, modifiers and man-hour values would all be adapted for Montana. Figures 11 and 12 show suggested forms for computing man-months required for each project. This is the most complex calculation required in using the system and can readily be completed manually with a hand calculator.

The "Pooled Fund" System was developed for construction engineering manpower management. Since preliminary surveys are done by the field construction crews in Montana, this work should be added to the system. Activities, contract types, standards and modifiers for preliminary surveys must be added to develop a complete system.

Allowances must also be made for the staff such as materials, design, traffic and utilities at division construction section offices who are included in the division's budget.

The Staffing element outlines procedures for estimating staffing needs by month to determine the best mix of permanent

Figure 10

TABLE OF
ACTIVITY PLANNING STANDARDS

Contract Type RECONSTRUCTION

CONSTR OPR	PLANNING ACTIVITY CODE	PLANNING ACTIVITY DESCRIPTION	PLANNING UNIT	BASE PLANNING VALUE	MODIFIER: UNDER TRAFFIC	MODIFIER: URBAN	MODIFIER: MOUNTAIN
EARTHWORK	01	Roadway Layout Staking	Roadway Mile	94	24	14	14
	03	Cross Sectioning and Slope Staking	Roadway Mile	61	16	15	12
	03	Grade Control -- Subgrade	Roadway Mile	64	13	13	6
	04	Removal and Relocation Inspection	Roadway Mile	10		15	
	05	Earthwork Inspection	Roadway Mile	80	20	80	16
	06	Density -- Earthwork and Drainage	Roadway Mile	30			
	07	Preparation for Construction -- Office	Roadway Mile	36		36	
	08	Earthwork -- Office	Roadway Mile	69			
DRAINAGE	11	Box Culvert and Minor Drainage Structure Staking	Roadway Mile	103	15	36	10
	12	Box Culvert and Minor Drainage Structure Inspection	Roadway Mile	74	19	148	
	13	Box Culvert and Minor Drainage Structure -- Office	Roadway Mile	67		67	
AGGREGATE	31	Line/Grade Control -- Aggregate Construction/Paving	Roadway Mile	57	9	14	6
	33	Untreated Aggregate Construction Inspection	Roadway Mile	44	13	33	
	33	Density/Gradation -- Untreated Aggregate Construction	Roadway Mile	22			
	24	Treated Aggregate Construction Inspection	Roadway Mile	44	13	22	
	35	Density -- Treated Aggregate Construction	Roadway Mile	6			
	26	Weigh Aggregate Construction Materials	Roadway Mile	40	12	20	
	27	Aggregate Construction -- Office	Roadway Mile	14			
ASPHALT PAVING	31	Asphalt Paving Inspection	1,000 Tons	13	3	7	3
	32	Asphalt Plant Inspection	1,000 Tons	11	3	6	2
	33	Weigh Asphalt Material	1,000 Tons	10	3	5	2
	34	Asphalt Paving -- Office	1,000 Tons	6			
PCC PAVING	41	Portland Cement Concrete Paving Inspection	1,000 Sq. Yds.	4	1	2	
	42	PCC Plant -- Paving	1,000 Sq. Yds.	2	1	1	
	43	Joint Repair Inspection	100 Sq. Yds.	22		11	
	44	PCC Paving -- Office	1,000 Sq. Yds.	1			
STRUCTURE	51	Structure Staking	Bent	16	2		
	52	Structure Inspection	Span-Lane	48			
	53	PCC Plant -- Structure	Span-Lane	11			
	54	Structure -- Office	Span-Lane	19			
MISC.	61	Staking Miscellaneous Items	Roadway Mile	91	14	32	9
	62	Inspection for Miscellaneous Items	Roadway Mile	66	17	33	7
	63	Office Work for Miscellaneous Items	Roadway Mile	55			
SPECIAL FEATURE	71	Special Feature Staking	Lump Sum	Estimate			
	73	Special Feature Inspection	Lump Sum	Estimate			
	73	Special Feature -- Office	Lump Sum	Estimate			
GENERAL	81	General Office Work	% Inspection Mil	15-30			
	82	Project Supervision and Management	% MH Act. 01-81	10-15			
	83	Standby	% Mil Act. 01-81	2			
	84	Travel	% Stkg. & Insp. Mil	See table			
	85	Training and Equipment Maintenance	% Mil Act. 01-81	1			
	86	Consultant Supervision	% MH Act. 01-81	2 – 4			

CONSTRUCTION ENGINEERING MANPOWER MANAGEMENT

MANPOWER PLANNING REPORT (TYPE A)

Contract Type _____

District
Contract No.
Date

CONSTRUCTION OPERATION	ACTIVITY CODE	PLANNING ACTIVITY	PLANNING UNIT	NUMBER OF PLANNING UNITS ×	STANDARD PLANNING VALUE (M-Hrs/Unit) =	MAN-HOURS REQUIRED ÷	MAN-HOURS PER MAN-MONTH =	EQUIVALENT MAN-MONTHS
EARTHWORK	01	Roadway Layout Staking	Roadway Mile				173	
	02	Cross Sectioning and Slope Staking	Roadway Mile				173	
	03	Grade Control -- Subgrade	Roadway Mile				173	
	04	Removal and Relocation Inspection	Roadway Mile				217	
	05	Earthwork Inspection	10,000 Cyds, RM				217	
	06	Density -- Earthwork and Drainage	10,000 Cyds, RM				217	
	07	Preparation for Construction -- Office	Roadway Mile				173	
	08	Earthwork -- Office	Roadway Mile				173	
		Total Earthwork Activities						
DRAINAGE	11	Box Culvert and Minor Drainage Structure Staking	Roadway Mile				173	
	12	Box Culvert and Minor Drainage Structure Inspection	Roadway Mile				217	
	13	Box Culvert and Minor Drainage Structure - Office	Roadway Mile				173	
		Total Drainage Activities						
AGGREGATE	21	Line/Grade Control -- Aggregate Construction Paving	Roadway Mile				173	
	22	Untreated Aggregate Construction Inspection	Roadway Mile				217	
	23	Density/Gradation -- Untreated Aggregate Construction	Roadway Mile				217	
	24	Treated Aggregate Construction Inspection	Roadway Mile				217	
	25	Density -- Treated Aggregate Construction	Roadway Mile				217	
	26	Weigh Aggregate Construction Materials	Roadway Mile				217	
	27	Aggregate Construction -- Office	Roadway Mile				173	
		Total Aggregate Activities						

Figure 11

CONTRACTOR OPERATION	ACTIVITY CODE	PLANNING ACTIVITY	PLANNING UNIT	NUMBER OF PLANNING UNITS	x STANDARD PLANNING VALUE (M-Hrs Unit)	= MAN-HOURS REQUIRED	÷ MAN-HOURS PER MAN-MONTH	= EQUIVALENT MAN-MONTHS
ASPHALT PAVING	31	Asphalt Paving Inspection	1,000 Tons				217	
	32	Asphalt Plant Inspection	1,000 Tons				217	
	33	Weigh Asphalt Material	1,000 Tons				217	
	34	Asphalt Paving -- Office	1,000 Tons				173	
		Total Asphalt Paving Activities						
PCC PAVING	41	Portland Cement Concrete Paving Inspection	1,000 Sq. Yds.				217	
	42	PCC Plant -- Paving	1,000 Sq. Yds.				217	
	43	Joint Repair Inspection	100 Sq. Yds.				217	
	44	PCC Paving -- Office	1,000 Sq. Yds.				173	
		Total PCC Paving Activities						
STRUCTURE	51	Structure Staking	Bent or Span				173	
	52	Structure Inspection	Span Lane or WD				173	
	53	PCC Plant -- Structure	Span Lane				173	
	54	Structure -- Office	Span Lane				173	
		Total Structure Activities						
MISC.	61	Staking for Miscellaneous Items	Rdwy Mile or WD				173	
	62	Inspection for Miscellaneous Items	Rdwy Mile or WD				217	
	63	Office Work for Miscellaneous Items	Rdwy Mile or WD				173	
		Total Miscellaneous Activities						
SPECIAL FEATURE	71	Special Feature Staking	Lump Sum	Est.			173	
	72	Special Feature Inspection	Lump Sum	Est.			217	
	73	Special Feature -- Office	Lump Sum	Est.			173	
		Total Special Feature Activities						
GENERAL	81	General Office Work	MH Insp. Act. Work Days, L. Sum				173	
	82	Project Supervision and Management	% MH Act. 01-81				173	
	83	Standby	% MH Act. 01-81				173	
	84	Travel	% MH Stkg. & Insp.				173	
	85	Training and Equipment Maintenance	% MH Act. 01-81				173	
	86	Consultant Supervision	% MH Act. 01-81				173	
		Total General Activities						
		Total Direct Activities						

Prepared by _____

Figure 12

and seasonal employees to handle the workload. One method is shown in Figure 13. Activities can be grouped by skill level to further define the number of employees needed in each classification. A typical skill level table is shown in Figure 14.

Budgeting

Standard costs are applied to the staffing estimates made in Planning and Staffing to develop a Budget based on the work to be done. In the "Pooled Fund" System, standard costs are based on labor costs plus fringe benefits plus an allowance for all other costs. (Labor and fringe benefits account for 85% of construction engineering costs.) Figure 15 shows the basic calculation.

This element would require the most tailoring to meet the current budgeting requirements for the State Budget and Accounting System. The number of line items in the budget process should be reduced to the vital few to reduce the time required to prepare budgets. Four line items accounted for 94 percent of the construction expenditures through April in the 1981 fiscal year.

With the exception of payments to contractors, cost standards can be developed for all required line items. The standard costs could then be applied to the man-months required to perform the workload. The procedure should include a provision for overriding any standard where field conditions require a deviation. Only non-standard costs would then need explanations to support the budget request.

Figure 13

CONSTRUCTION ENGINEERING MANPOWER MANAGEMENT

ANNUAL MANPOWER DISTRIBUTION PLAN

(TYPE A)

Contract No. | Contract Type
Dist-Proj.
Est. Completion Date | Est. Start Date
Date Prepared | Year

STAFFING ACTIVITY	PLANNING ACTIVITIES COMBINED (ACT. CODES)	COMBINED TOTAL CONTRACT PLAN	MAN-MONTHS USED TO DATE	MAN-MONTHS REMAINING	YEARLY DISTRIBUTION JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	STAFFING YEAR TOTAL
Preliminary Staking	01 - 02																
Earthwork	03 - 08																
Drainage	11 - 13																
Aggregate	21 - 27																
Asphalt Paving	31 - 34																
PCC Paving	41 - 44																
Structure	51 - 54																
Miscellaneous	61 - 63																
Special Feature	71 - 73																
General Office	81																
Supervision	82																
General	83 - 86																
TOTAL DIRECT ACTIVITIES																	

TABLE OF STAFFING ACTIVITY SKILL LEVEL GUIDELINES

Contract Type RECONSTRUCTION

STAFFING ACTIVITY	PERCENT OF TOTAL STAFFING				
	Tech V	Tech IV	Tech III	Tech II	Tech I
Preliminary Staking		20	15	35	30
Earthwork		35	25	25	15
Drainage			60	30	10
Aggregate			25	45	30
Asphalt Paving			70		30
PCC Paving		15	45	40	
Structure		25	60	10	5
Miscellaneous			50	20	30
Special Feature			Estimate		
General Office Work			50	50	
Project Supervision and Management	100				
Consultant Supervision	100				

Figure 15

CONSTRUCTION ENGINEERING MANPOWER MANAGEMENT

CONSTRUCTION ENGINEERING BUDGET REPORT

DISTRICT

BUDGET YEAR

DATE PREPARED

CONTRACT NUMBER	CONTRACT TYPE (*)	TOTAL MAN-MONTHS FOR BUDGET YEAR	X	STANDARD COST (Dollars/Man-Month)	=	TOTAL COST
				TOTAL →		

* Contract Type	Code	* Contract Type	Code
Construction	1	Intersection Improvement	6
Reconstruction	2	Safety and Traffic Control	7
Widening and Resurfacing	3	Miscellaneous	8
Resurfacing	4	Unique	9
Bridge Repair	5		

Scheduling

The Scheduling element describes methods of preparing weekly schedules and the use of secondary assignments to use manpower effectively. Since the Department is already using secondary work assignments, little tailoring will be required.

Monitoring

The Monitoring element provides for comparing planned manpower with that actually used and the contractor's progress throughout the project. If the use of manpower is controlled, eighty-five percent of the engineering costs will be controlled. Monitoring only the key items reduces the level of detail without sacrificing the level of control. An example monitoring report is shown in Figure 16.

System Updating

All standards, procedures and systems must be reviewed periodically to ensure that they are current. Updating procedures provide for systematic reviews.

Work Methods Improvement

There is a need for continual evaluation of methods, equipment, materials, etc., used in highway construction. Procedures -- particularly paperwork -- are often implemented to correct specific problems, but are continued in practice long after the problems were solved. If employees are to be used efficiently, the Department must eliminate any unnecessary work and outmoded practices and implement up-to-date procedures.

CONSTRUCTION ENGINEERING MANPOWER MANAGEMENT

DISTRICT MANPOWER REPORT

(TYPE A)

☐ SUMMARY

☐ EXCEPTION

Contract No.

Period Ending

CONTRACTOR OPERATION	MAN-HOURS				KEY BID ITEM				REMARKS
	PLANNED	USED TO DATE	REMAINING	PERCENT USED	UNIT	PLANNED	COMPLETE TO DATE	PERCENT COMPLETE	
Prelim. Staking									
Earthwork									
Drainage									
Aggregate									
Asphalt Paving									
PCC Paving									
Structure									
Miscellaneous									
Special Feature									
General Office									
Supervision									
General									
Total Contract									
PERCENT CONTRACT COMPLETE (DOLLARS)									
PERCENT CONTRACT TIME USED (DAYS)									

Engineer-in-Charge

Figure 16

Recommendation:

> It is recommended that a Work Methods Improvement Committee be established to identify and evaluate work methods for improvement.

Many of the problems identified in Chapter Two could be resolved through the efforts of this committee. The work of the committee should be coordinated with the development and implementation of the construction management system but it can be implemented independently. The committee should report to a Steering Committee of top-level managers so that potential improvements will not be lost in the chain of command.

Personnel Classifications

Personnel classification plans should support good construction manpower management by rewarding those with the ability and willingness to perform a variety of assignments. Employees should be promoted because they have demonstrated their ability to effectively perform the work. The classification plan should be specific in the requirements for promotions so it is clear to both employees and supervisors exactly what employees must do to qualify.

Time did not permit a thorough evaluation of the personnel classifications for construction personnel. However, the examples of work performed in the position descriptions includes surveying for both preliminary surveys and construction, inspection and office work. Supervisors indicated that most technicians are indeed versatile. This should be verified during the development and implementation of the construction management system.

Recommendation:

> It is recommended that the current personnel classification plan be evaluated to ensure that it does support manpower management. If it does, no changes will be needed. If it does not, the plan including position descriptions and promotional criteria, should be revised.

Training

The Construction Bureau's training program consists of five courses conducted by Montana State University at Bozeman. They are:

- Basic Supervisory Training,
- Construction Inspection Materials,
- Construction Inspection Surveying,
- Intermediate Surveying, and
- Advanced Surveying.

Each course lasts a week. The first three courses were each conducted once this past winter. The last two were conducted twice. All trainees must travel to Bozeman to participate in these courses.

Since these courses are held in the winter months, they are not available for training seasonal employees. Seasonals are trained on the job. With the high percentage of seasonal employees typically employed during the last five years and the number of permanent employees to train, a training program that can be conducted in the project or division construction section offices appears to be warranted.

Additional training for construction personnel was cited as a way of increasing the versatility of permanent employees and improving the uniformity of inspection. Actual training needs are best determined through the conduct of a training needs analysis.

Recommendations:

> It is recommended that a training needs analysis be made to determine the critical training needs in construction.
>
> It is recommended that a training program then be designed to satisfy the needs identified in the training needs analysis.

The training needs analysis and program design can either be included in the construction management improvement project or completed separately. Once the training program is designed, development of the individual courses should be completed in a separate undertaking.

ORGANIZATIONAL CONSIDERATIONS

The current organization for construction has only three levels of management -- Project Manager, Division Construction Section Supervisor and Chief - Construction Bureau. This is the lowest number of levels practical for an operation of this complexity. In the Consultant's opinion, the current organization adequately meets the needs of the construction function.

Most highway departments have divided their states into districts supervised by district engineers. Usually the district

engineer is responsible for maintenance, equipment repair, construction, and all other activities in the field and district. The greatest advantage to this position in Montana would be the potential for improved coordination of maintenance and construction efforts. Any level of management added must pay for itself in increased efficiency of the overall operation.

Central vs Decentralized Authority

Authority in the Construction Bureau is centralized. Many of the decisions could be delegated to the Division Construction Section Supervisors. For example, all change orders must be submitted to Helena for approval whether they document changes in quantities or involve major changes in the project design. Many highway departments have authorized division construction supervisors, or their counterparts, to approve change orders below a preset dollar value, typically $10,000 to $25,000. Approval of changes in design or specifications normally is not delegated. Guidelines must be developed and field supervisors trained in the use of the guidelines and authority before the change should be implemented, of course. The Construction Bureau would continue to monitor change order approvals to ensure conformance with the guidelines.

Approval of overtime and travel allowance is another example of work that could be delegated to the Division Construction Section Supervisors.

Recommendation:

> It is recommended that more decisions and authority be delegated to the Division Construction Section Supervisors.

Control can be maintained by spot checking to identify problems if supervisors take too much or too little authority. This recommendation follows the management principle of delegating decisions to the lowest level capable of making them. Requiring Division Construction Section Supervisors to assume this additional responsibility will:

- free the Construction Bureau of approvals that are essentially "rubber stamp" decisions;
- expedite decisions in the field; and
- provide more decision making experience to develop managers.

Preliminary Surveys and Design

All eleven division construction sections conduct preliminary surveys for design. Eight have road design capabilities. Most preliminary surveys are conducted in the winter months when field construction personnel have slack time even though ground conditions may be unfavorable. More of this work could be done with photogrammetry but total Department costs would rise unless productive work can be found to replace it.

A few sections now use field construction project managers and technicians to assist their designers in the winter. Utilizing construction personnel effectively in design requires careful planning. Additional lead time will undoubtedly be required. However, the use of construction personnel in design will utilize time that otherwise might not be used effectively. It would also improve the communication of problems in preliminary surveys, design and construction between construction and design.

Recommendation:

> It is recommended that more roadway design be delegated to the division construction sections to utilize the capabilities of field construction personnel during the off-season.

Any increase in assignment of design to the division construction sections must be accompanied by an equal reduction in staffing of the road design unit in central office if total costs are to be maintained or reduced.

IV. ANALYSIS OF ALTERNATIVES

The Department has several options, including implementing all of the recommendations, selected ones, or portions of individual recommendations. The major alternatives are discussed in this section.

ALTERNATIVE NO. 1 -- COMPLETE SYSTEM

The Consultant recommends that the Department develop and implement all elements of the construction engineering manpower management system including planning, staffing, budgeting, scheduling, monitoring, improving work methods, evaluating personnel classifications, analyzing training needs and designing a training program.

This approach will provide a complete management system for the construction function plus improved work methods, improved personnel classifications, if they are needed, and a training program design for critical training needs. All elements, developed together, will complement each other.

In addition to the advantage of having a complete system, this alternative will be more cost effective. Data will be collected once for all elements. The tasks can be coordinated to utilize the development staff's time more efficiently. Travel costs can be reduced. The work will be completed in a shorter total time to reduce disruption in the Department.

The major advantage is that the Department will have the benefit of the use of the system at the earliest practical time.

ALTERNATIVE NO. 2 -- BASIC SYSTEM

This alternative involves developing and implementing the basic construction management system -- planning, staffing, budgeting, scheduling and monitoring -- but deferring improving work methods, evaluating personnel classifications, analyzing training needs and designing a training program.

The major advantage of this alternative over implementing the complete system is a small reduction in cost.

ALTERNATIVE NO. 3 -- BUDGETING SYSTEM

Another less attractive alternative is the development and implementation of only the performance budgeting element. Development of a performance budget requires that budget needs be related to the workload. The most logical method for accomplishing this for the construction function is through the use of the planning and staffing elements of the "Pooled Fund" System. Through the use of contract types, staffing standards and the like, staffing needs are determined to match the workloads. The budget is then prepared using the staffing needs and standard costs.

Because the planning and staffing elements are needed to support the budgeting element, development costs are nearly the same as for the basic system. Only scheduling and monitoring need to be added. In the Consultant's opinion this alternative is not in the Department's best interests and is not recommended.

V. RECOMMENDED DEVELOPMENT PLAN

The development tasks, schedule and costs and cost/benefits are discussed in this section.

DEVELOPMENT TASKS AND SCHEDULE

Mangement Improvements

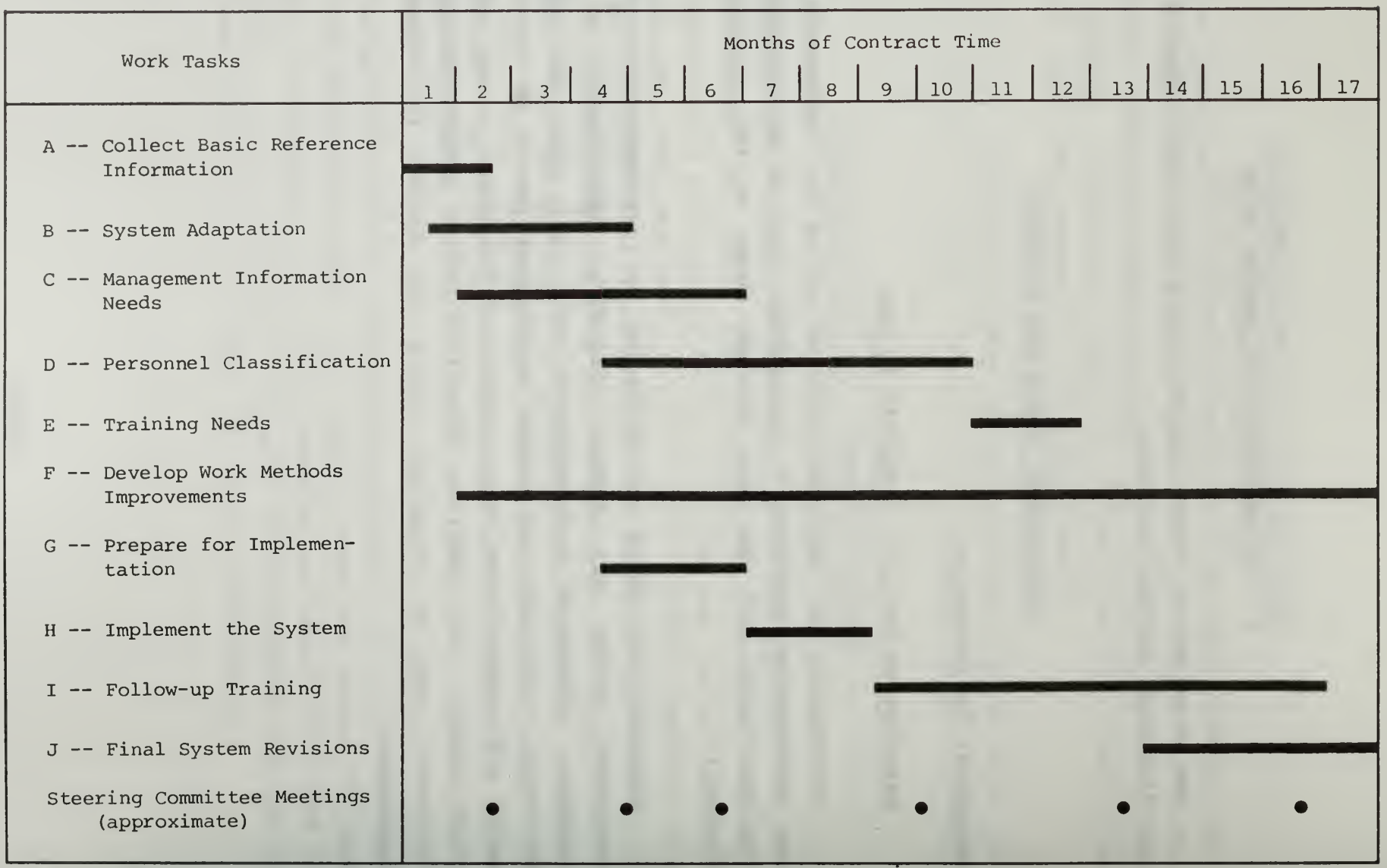
Alternative No. 1 -- Complete System

Development and implementation of all of the recommendations for construction management improvements can be accomplished in the ten tasks and the time periods shown on the schedule in Figure 17.

Adapting the system and preparing for implementation can be completed within six months following commencement of the project. Statewide implementation will take about two months. Follow-up assistance and system monitoring should be continued until all system users fully understand the sytem -- say another eight months. Any problems identified during implementation and follow-up must be resolved before the system is considered complete.

Figure 17

GENERAL PROJECT SCHEDULE -- COMPLETE SYSTEM



Alternative No. 2 -- Basic System

Development and implementation of the basic system can be accomplished in seven tasks as shown in Figure 18. The time required is essentially the same as for the complete system.

Alternative No. 3 -- Budgeting System

Because this alternative is not recommended, a development plan was not prepared.

Organization Considerations

The recommendations for decentralizing authority and roadway design can be accomplished in conjunction with regular Department workloads. No tasks, schedules or costs were developed for implementing these recommendations.

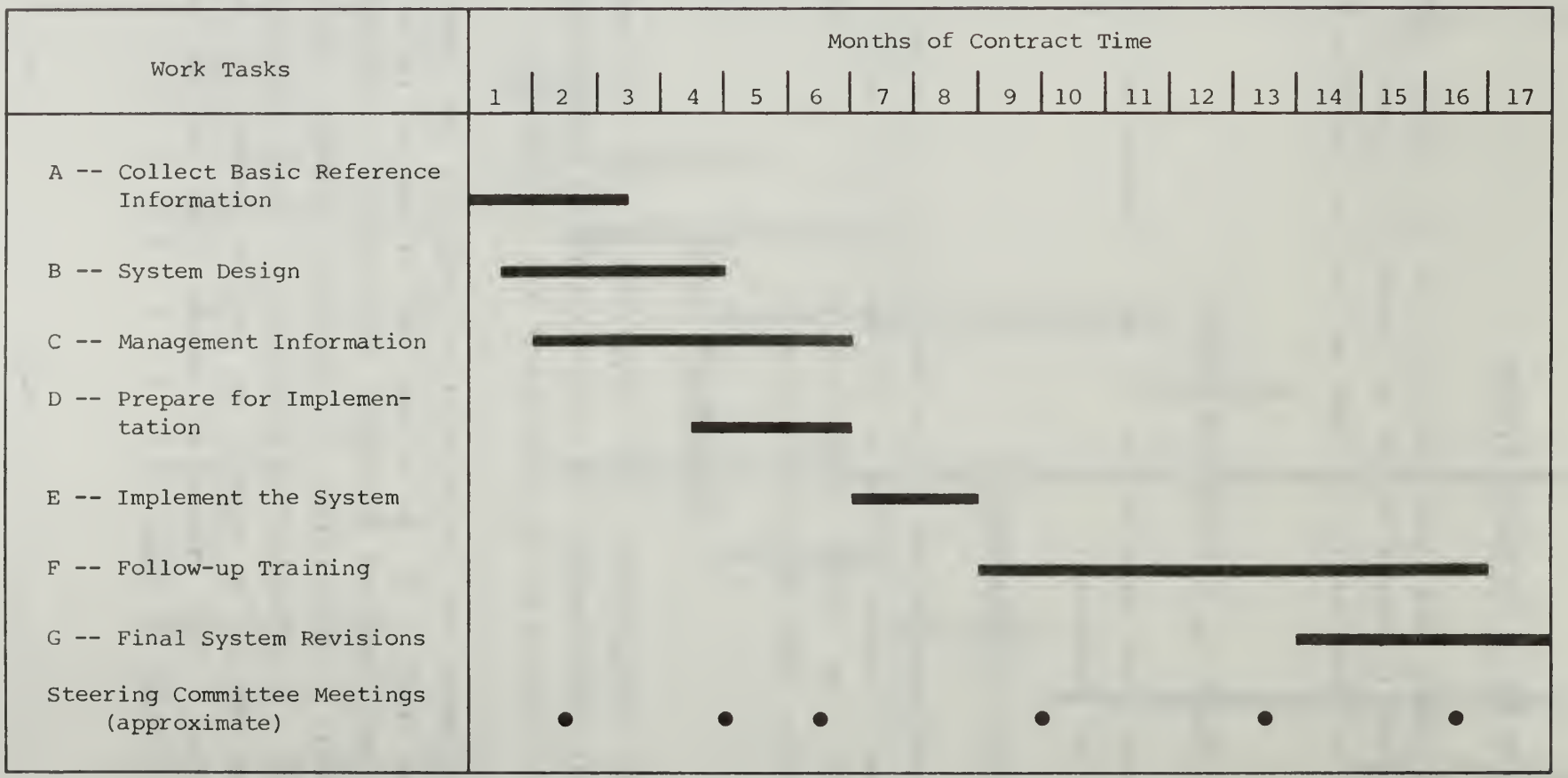
DEVELOPMENT COSTS

It is recommended that development and implementation of management improvements for construction be accomplished through the joint efforts of the Department and a consultant.

Development and implementation requires the commitment of a full-time staff. It is a one-time effort of relatively short duration and requires personnel experienced in management system development. Recruiting a qualified in-house staff would be difficult. A consultant experienced in construction engineering management should be engaged to provide overall guidance to the undertaking. The consultant would also provide an outside, objective point of view.

Figure 18

GENERAL PROJECT SCHEDULE -- BASIC SYSTEM



Department personnel should assist with development and implementation of the system to:

- ensure that it is practical for Montana,
- thoroughly understand the system so it will be fully utilized and readily updated, and
- reduce costs.

The consultant staff should include:

- a principal associate to provide overall supervision -- 4 man-months;
- a resident project manager to provide day-to-day direction of the work and continuous participation in all phases -- 17 months;
- additional professional personnel as required to maintain the schedule.

The Department staff should include:

- a Steering Committee responsible for adopting overall policies for the project, evaluating progress, reviewing findings and recommendations and approving the elements for implementation. Six one-half day meetings will be required.
- Technical Panels to assist with adapting the "Pooled Fund" System, evaluating personnel classification and training needs. Technical Panels will meet for a day or two at a

time, approximately ten times during the course of the project.

- a Work Methods Improvement Panel to identify, evaluate and recommend improvements for implementation with the guidance and assistance of the consultant. This panel will meet for one day at a time, approximately twelve times during the project period.

- a Project Coordinator to serve as principal liaison between the Department and the consultant and work directly with the project staff on all critical aspects of the work.

- a senior construction technician to assist in data collections and analyses.

- a project clerk, about half-time.

- part-time typing, word-processing, clerical and drafting personnel on a short-term, as-available basis.

Estimated costs for Alternatives 1 and 2 are tabulated below.

	Alternative 1	Alternative 2
Department Costs	$175,000	$155,000
Consultant Costs	225,000	200,000
Total	$400,000	$355,000

SAVINGS AND BENEFITS

The major benefit of developing and implementing the management improvements will be more effective utilization of manpower while maintaining or improving the quality of inspection. Better utilization of manpower will reduce construction engineering costs.

Construction engineering costs have averaged over ten percent in all but two of the last eight years. Based on experience in other states, it is reasonable to expect that C.E. costs can be reduced by an average of one percent of contractor payments through the implementation of the complete system. The results of implementing the basic system would be somewhat less, at three/fourths of one percent.

The contractor earnings for the last five years have averaged $88 million per year. If this average holds, the following cost/benefits can be expected.

Alternative No. 1 -- Complete System

Estimated 5-year savings	$4,400,000
Development and implementation costs	

Cost benefit ratio -- 1:11.0

Alternative No. 2 -- Basic System

Estimated 5-year savings	$3,300,000
Development and implementation costs	355,000

Cost benefit ratio -- 1:9.3

The cost of development is a one-time cost. Annual costs of running the system are minimal. The benefits of the management improvements will continue for more than the 5-years.

In addition to the potential improvement in the utilization of manpower, implementation of a construction engineering manpower management system will provide the Department with the capability to:

- uniformly determine staffing needs for the various mixes of projects assigned to the division construction sections;

- determine if adequate staff is available to ensure proper inspection;

- identify the need for off-season assignments;

- identify the number of employees needed in each skill level--both permanent and seasonal--to handle the workload;

- develop performance budgets based on the workloads, staffing standards and standard costs; and

- monitor the use of manpower--the major construction engineering cost.

Work methods Improvement Committees have been successful in eliminating unnecessary work and improving ineffective procedures. Many of the problems identified in Chapter Two can be resolved through the efforts of this committee.

Evaluation of the personnel classification plan will determine whether the current plan supports manpower management as it should. If improvements are needed, they will include work based criteria for evaluating employees' performance for promotion. Any criteria for promotion developed will require that employees become versatile to qualify.

The training needs report will provide a listing of any critical needs and outline a training program to meet those needs so the training budget will be spent where training is most needed.

BN:snk:208D

R.J. HANSEN ASSOCIATES, INC.

MANAGEMENT AND INFORMATION SYSTEMS CONSULTANTS

PROJECT PRIORITY

MANAGEMENT INFORMATION NEEDS ANALYSIS

FOR THE

DEPARTMENT OF HIGHWAY
STATE OF MONTANA

July 1981

FINAL REPORT
PRIORITY PROGRAMMING SYSTEM
SYSTEM FEASIBILITY STUDY

STATE OF MONTANA

DEPARTMENT OF HIGHWAYS

JULY 1981

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I. INTRODUCTION

The Montana Department of Highways has taken the initial step toward identifying the overall organizational and management information needs of the Department and laying out plans to meet these needs.

The information needs of Priority Programming have basically been met by the Planning and Research Bureau as far as information system development is concerned. Therefore, this report focuses specifically on management decision-making and organization aspects related to the Priority Programming Process.

The information resource that is available must now be properly utilized and managed in a more timely fashion to aid in the decision-making process.

Management of programs requires the clear definition of work scope, needs and objectives as a basis for planning and controlling each program. The translation of program needs and objectives into operating plans and budgets occurs at all organizational levels to varying degrees. It is vital that the manual and automated processes to be implemented will provide the information appropriate to management at all levels.

A primary purpose in expanding and making more effective use of project formulation, seletion, and the priority process is to support the planning and control necessary to fulfill the mission of the Department and its need to "catch-up" with the deteriorating roadway system.

A. PROJECT BACKGROUND AND OBJECTIVES

As the roadway ages, it becomes critical to assure that construction, rehabilitation, and betterment levels are adequate to protect the highway investment.

The budgeting and planning problem to protect this investment and to continue to provide adequate service to the motorist is complicated by the limited resources and the management processes to fund and schedule the projects. Effective planning must be based upon total need, where each project must compete for the limited funds available. Therefore, it is desirable for the most needed work to be done first. This has required a means of arraying proposed improvements into a priority order.

The Department has already embarked on the development and implementation of a new planning system to prioritize projects needs into the work programs, listed here:

- Reconstruction Program
- Widening and Rehabilitation Program
- Resurfacing Program
- Bridge Replacement Program
- Hazard Elimination Program
- Rail-Highway Safety Program

The above work program priority arrays have achieved the following objectives toward a formal project selection process:

- Established common bases for identifying needs.
- Established the capability to perform statewide roadway system analysis.

- Established an information base to be responsive to the administration.
- Promotes sound management practice by emphasizing department-wide needs.
- Provides the means to allocate dollars based on needs.
- It can define the needs as a basis for two, six, and twenty-year planning.

The above objectives seem to have been met in the planning process of priority arrays. The next phase of the implementation of Priority Programming now must deal with the management aspect of organizing for programming the projects within the available funds, communicating the plan, and working the plan.

B. SUMMARY OF RECOMMENDATIONS

- Establish Planning and Programming Division support in headquarters.
- Establish a Priority Programming function within the above division that would manage and coordinate a planned Priority Programming Process.
- Incorporate the Planning and Research Bureau into this division and extend the use of their planning information into Project Control functions.
- The Project Control Unit will be a part of this Division to translate the planning information into work programs and schedules.
- The project and manpower management functions of the Project Control Unit should remain in the Engineering Division.
- Incorporate planning methods for the Field Division Managers to help create, review, and approve the work programs for projects within the respective Field Divisions.
- Refine existing project evaluation factor weights to reflect the Department's strategic plan.
- Expand the Action Plan to promote more public involvement through the use of a pre-allocation hearing process -- while projects are being identified, formulated, and programmed.
- Through Value Engineering methods, initiate a systematic review and analysis of existing standards, specifications, and design guides.
- Integrate the Pavement Management System into the Project Formulation, Selection, and Priority Process.
- Initiate a continuing highway needs study covering the Primary, Secondary, and Interstate systems.
- Develop a Statewide Transportation plan.
- Pursue the implementation plan of using this system as one of the highest priority in the Department.

- Establish two and six year plans using the published 5-Year Construction Plan, priority programming, and down-scoping. The annual element (105 program) will be extracted from the two-year plan.

II. SUMMARY OF FINDINGS

There are increasing pressures to sustain the life of the existing road network of the State, but rising costs, declining revenues, and accelerating roadway deterioration are only a few of the obvious problems preventing the MDOH from accomplishing their mission. The Department has found that a priority programming process has helped in strategizing a plan to keep the road networks at an acceptable tolerable level, but there has not been an organized follow-thru. Strategizing means planning. Planning includes assessing the total improvement needs to allocate the highway dollar where it counts the most. And assessing the total needs implies "Planning the work and working the plan." Our findings clearly indicate that there are planning tools available, but that no organized procedures have been established to carry thru with a strategic plan or to equitably select program needs based upon a priority of those needs, and thus, to work the plan to completion.

A. OVERVIEW OF CURRENT SITUATION

It was the general consensus of Steering Committee Members that improved top management, overall direction and control has been needed for quite some time. Part of the need was derived from past centralization of decision-making in the Department. It was apparent, based upon interviews and observations by Consultant

† That top level managers in the past devoted a great deal of their time to matters which were quite short-range in nature.

† That, due to the preceeding, little time could be devoted to the long-range direction of the Department.

† Strategic plans and strategies to "get where the Department wants to go" were not given the attention warranted by existing conditions.

† That, also due to the above, the Department's past management processes were characterized by crisis-type decision-making actions.

Conclusion. There was a real need for the Department to take the action that it did to implement a decision-making process with managers at the lowest practicable level -- and to clearly define the basic responsibilities and key tasks of top management.

The Consultant has observed that the following changes in MDOH are in the process of being implemented at this time and each will contribute to achieving an ultimate strategic plan, they are:

1. Decentralization of decision-making will allow top management to devote the time needed for long-range planning and policy making.

2. A "Team at the top" concept of management has long been needed as the key tasks to be performed are beyond the capabilities of one or two individuals.

3. Key decisions are now being defined and scheduled in a systematic manner.

4. A disciplined approach is being taken to prevent decisions which should be made at lower levels from "sifting to the top."

Growth in categorical Federal-Aid fund programs has increased to an unmanageable number. There are now 24 separate apportionment codes for federal funds related to construction. When other special categories of state funds are added, the total amounts to over 30 separate funds that must be planned and managed by MDOH.

This number of funds reduces the flexibility in project formulation since federal-aid and state funds must be "matched" to a greater number of specific projects.

The 1974 Needs Study is the last analysis made of the total needs of the Rural Primary System. There are projects listed in the 5-year construction plan of 1974 that can be found in the 1981 construction plan. So how good is the planning process when most schedules are not met? Short-term planning and crisis management no doubt contributed.

Total needs were not considered in 1974 for such programs as the Secondary System, the Urban System, or Interstate so the total estimated dollar needs have never been known and thus a complete plan could not be formulated. The more comprehensive a plan, the better the opportunity to fully achieve the plan.

Further, the existing planning processes still consider each categorical fund separately in determining an array of priorities. Therefore, the allocation of funds may be made to satisfy federal categories and not necessarily the most critical needs of a state. For instance, when should funds be allocated for bridge

repair over that of pavement rehabilitation. Each improvement must somehow be weighed in total to best allocate funds in an equitable way.

Priority arrays are now being developed by the Planning and Research Bureau for the following individual fund programs, they are:

PRIMARY

- Reconstruction
- Primary 3R

HIGHWAY BRIDGE REPLACEMENT & REHABILITATION PROGRAM

- Interstate Highway Bridges
- Primary Highway Bridges
- Secondary Highway Bridges
- Urban Highway Bridges
- Off-System Bridges

RAIL HIGHWAY CROSSING SAFETY PROGRAM

SAFETY IMPROVEMENTS PROJECTS

- Hazard Elimination Program

URBAN SYSTEM

There are no sufficiency ratings for these systems:

INTERSTATE SYSTEM

SECONDARY SYSTEM

The Planning and Research Bureau does have a proposed procedure for developing a sufficiency rating for the Interstate System by individual directional lanes. It is planned to

complete a sufficiency rating of the Interstate during this calendar year.

There are no current plans for developing sufficiency ratings for the Secondary System.

Conclusion. To compile the total highway needs of the State, it is recommended that a needs study be developed for the Secondary System. The 1974 Primary Needs Study must also be updated. With the total needs then known, a more realistic allocation of funds can be made to each of the systems and work programs using the process of Priority Programming.

Conclusion. The Planning and Research Bureau has much of the needed Priority Programming Process designed and in place that will utilize the H.I.S. (Highway Information System) data including the road log, sufficiency data, accident information as well as preliminary evaluation of social, economic, and environmental impact.

Conclusion. While there are existing project evaluation methods available, extensive study should be conducted on the actual criteria and factor weights, i.e., benefits of extending road life values versus safety factors.

Conclusion. There needs to be authorization to develop a complete Priority Programming Process. A commitment should be made by top management to use the executive team concept to formulate the total work program.

B. HOW SUFFICIENCY RATINGS ARE APPLIED

The Department carries out a program of annual sufficiency ratings of Primary Highways data collected on the geometric characteristics and surface conditions of the various road sections. Evaluations are made to define the degree of sufficiency on the following items:

†	Foundation	10 points
†	Surface	30 points
†	Drainage	10 points
†	Safety	20 points
†	Capacity	30 points

A completely adequate section, most likely newly constructed, would be rated at 100 points. Ratings are adjusted to reflect traffic volumes, thus giving additional priority to sections carrying above-average traffic volumes.

As the Road Life Cycle progresses from new to old, the sufficiency rating lowers in value and varying work programs must be applied as shown in the following table.

Sufficiency Rating Points	Typical Work Program Required	Approx.* Cost Per Mile	Typical** Life of Improvement
70-100	Regular Mtce.	$ 3,000	Annually
50-70	Special Mtce.	20,000	7 Years
50-60	Resurfacing	90,000	10-15 Years
30-50	Rehabilitation	225,000	10-20 Years
0-30	Reconstruction	550,000	20-25 Years

* The above costs can vary greatly depending upon age of road, location, traffic, sub-structure, etc.

** Estimated life in years, not exact and used here as example only.

The curve on the following page is a plot of the accumulated mileage by sufficiency ratings from 0 to 100 for the Rural Primary System. The table below was created from the sufficiency curve and depicts the broad global dollar needs to upgrade to an allowable tolerable level. It is suggested that these improvement, miles and dollars, must be made over the next 6 to 7 years as more highway sections will be in need of rehabilitation at the end of that period.

RURAL PRIMARY SYSTEM

1980 Suff. Rating Group	Work Program To Achieve Tolerable Level	No. of Miles	Cost/Mile to Improve	Total Cost By Group
0-30	Reconstruction	140	$550,000	$ 80,000,000
31-50	Widen & Rehab.	1,200	225,000	270,000,000
51-60	Resurfacing	1,325	90,000	120,000,000
Total 6-7 Yr. needs for Rural Primary System		2,665		$470,000,000

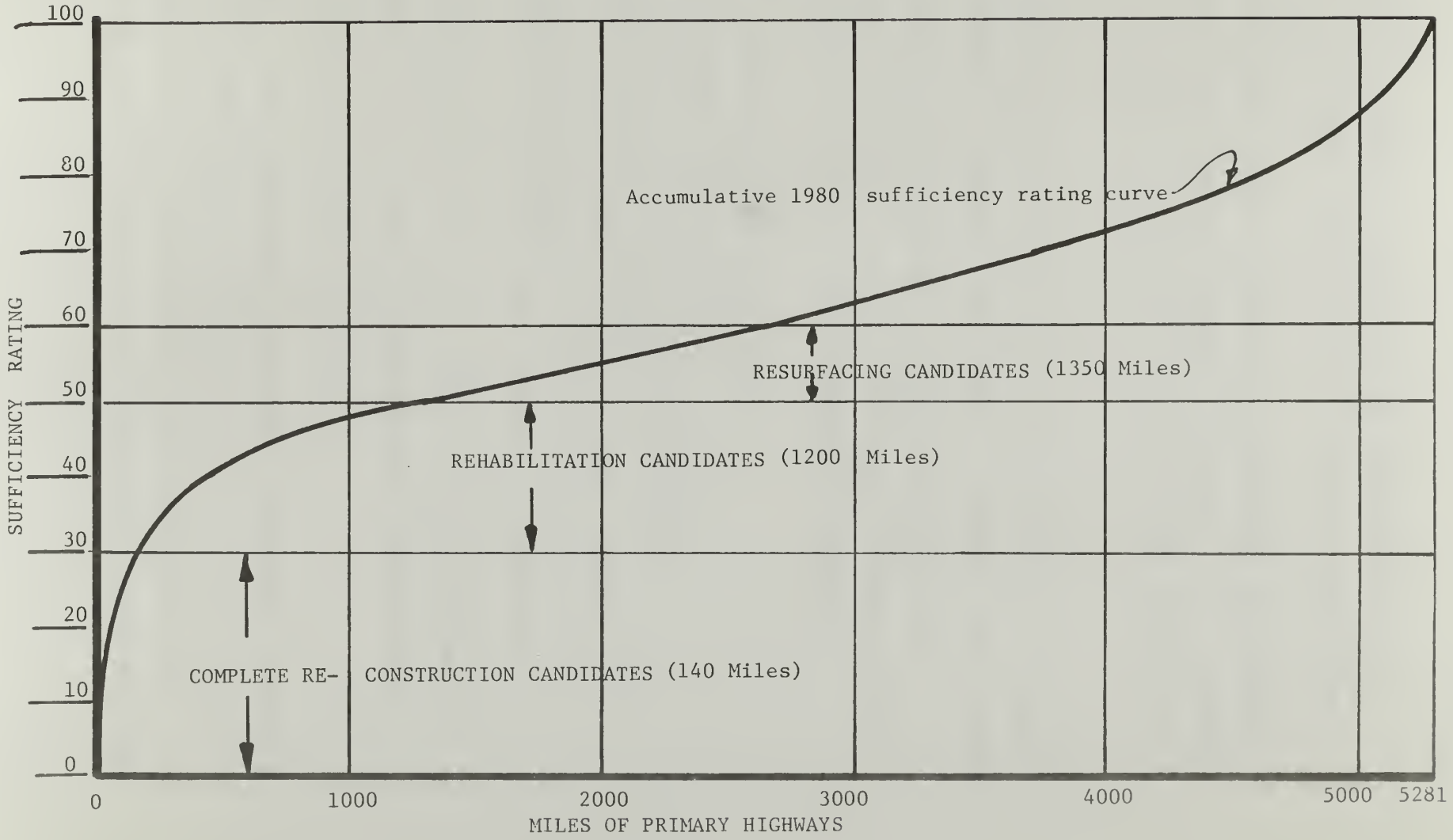
Conclusion. The Department has currently $20,000,000 programmed this year for the Rural Primary System. If this rate continues, there actually is a shortfall of $50 to $60 million per year needed to raise the primary system to a tolerable level during the next 6 or 7 years.

C. OTHER PRIORITY ARRAYS

For the Bridge Rehabilitation and Replacement Program there is a Bridge Sufficiency Rating being used to establish the eligibility for replacement on rehabilitation. Rating categories now

GENERAL CRITERIA FOR A SUGGESTED 6 YEAR PLAN

FEDERAL AID PRIMARY SYSTEM



exist as defined by Federal Department of Transportation to describe the functionally obsolete or structurally deficient.

Comparative significance ratings are calculated to indicate the importance of the bridge to remain in service, i.e., priority of needs, and is used for the basis for determining statewide priorities.

Another work program that has been prioritized is the Hazard Elimination Program. Locations that are included in this program come from a computerized accident information system that assesses various parameters for sections called "cluster areas." The prioritization is listed in the following categories:

- High Severity Clusters
  Injury and Fatal Accidents
- High Accident Rate Clusters
  Number of Accidents by Vehicle Miles
- Number-of-Accident Clusters
  Pin-Points Specific High Accident Location
- Intersection Clusters
  With Higher Than Normal Number of Accidents

Another priority array that is created by the Planning and Research Bureau is for the Rail-Highway Safety Program which locates and identifies problem crossings.

Conclusion. There are several Priority Programming Processes operating in the Department to portray needs, but there is an overall planning gap that has prevented the Department from creating the type of strategic plan to gain public acceptance for

the needs and legislative backing to fund the needed programs.

On the following pages are several working papers now being used for establishing priorities. They include:

- † Tentative priority listing for resurfacing and minor widening projects.
- † Deficient bridge area and percentage by Financial Districts.
- † Temporary priority rankings for Primary System.
- † Ranking for Improvement Type 7 (overlay) for a Financial District.
- † Ranking for Improvement Type 5 (minor widening) for a Financial District.
- † Primary Bridge Replacement and Rehabilitation Priority List as of April 10, 1981.

TENTATIVE PRIORITY LISTING
RESURFACING & MINOR WIDENING PROJECTS
(3 R)

REV 4-1-81
Date 12-31-79

Financial District #4

Combined Ranking (1)	Federal-Aid Sys & Rte	Begin Milepost	Length - Miles	Type of Improvement (2)	Estimated Cost - Dollars	VMT	Cost Vol Ratio (3)	HPR Index (4)	Division Recommend	Programmed Date & Project	Contracted Date
1	P20	23+0.110	5.8	7	$ 302,000	10411	29	78	3	APRIL 1981 FR20-1(10)T	APRIL 19[illegible] FR20-1(10)F
2	P20	18+0.596	4.2	7	229,000	7992	28	89	4	APRIL 1981 FR20-1(10)A	APRIL 19[illegible] FR20-1(10)[illegible]
3	P62	29+0.721	3.6	5	345,000	3481	99	56	2		
4	P62	24+0.961	4.7	5	450,000	4465	100	55	1		
		[illegible]491	11.0	5	1,053,000	5698	184	72	7		
						7320	330	51	10		

PRIMARY SYSTEM
DEFICIENT BRIDGE AREA AND PERCENTAGES BY FINANCIAL DISTRICT

DATE 2/27/81

FIN DIST	NO OF BRIDGES	BRIDGE AREA	ELIGIBLE FOR REPLACEMENT			ELIGIBLE FOR REHABILITATION				PERCENT DEFICIENT	PERCENTAGE FOR ALLOCAT.
			NUMBER	PERCENT	AREA	NUMBER	PERCENT	AREA	DEFICIENT AREA		
1	69	500,519	15	22	97,953 1.	33	48	199,703	71,893 4.	33.9	14.0 2.
2	56	182,588	12	21	43,797 5.	34	61	106,917	38,490 9.	45.1	6.8 7.
3	135	480,877	9	7	53,242 3.	103	76	263,802	94,969 3.	30.8	12.2 3.
4	90	345,949	8	9	59,342 3.	56	62	116,617	41,952 8.	29.3	8.3 5.
5	100	244,712	2	2	9,844 12.	77	77	169,603	61,057 6.	29.0	5.8 9.
6	102	465,488	7	7	41,659 6.	71	70	289,100	104,076 1.	31.3	12.0 1.
7	54	200,796	12	22	25,277 8.	26	48	56,312	20,272 11.	22.7	3.8 11.
8	88	488,315	20	23	84,926 2.	45	51	285,083	102,630 2.	58.9	15.5 1.
9	55	152,014	5	9	23,085 10.	25	45	33,003	11,881 12.	23.0	2.9 12.
10	78	284,471	3	4	11,049 11.	49	63	153,544	55,276 7.	23.3	5.5 10.
11	103	298,532	5	5	32,118 7.	65	63	98,286	35,383 10.	22.6	5.6 9.
12	109	333,173	7	6	24,260 9.	84	77	190,328	68,518 5.	27.9	7.6 6.
TOTAL	1,039	3,977,434	105	10%	506,552	668	64%	1,962,298	706,427	30.5	100.0
					12.7%				17.7%		

TENTATIVE PRIORITY RA[illegible] PRIMARY ROUTE PROJECTS

IN FINANCI[illegible]STRICT #4

Project No.	Project Designation	Type of Work	County	Length	FA Route No.	Beginning Milepost	Ending Milepost	Present ADT	Proposed Cost (000)	Lifetime Improvement	Projected [illegible]	Local Affected Population	Corridor Affected Population	Regional Affected Population	Existing Sufficiency Rating	Proposed Sufficiency Rating	SEE Impact Rating	Cost Effect. Index(P)	CE Ranking	Accident B/C Ratio	BC Ranking
0-2( )52	Central-2nd Sidney	Signals	42		20	52.226	---	5,810	60	10	1,000	5,629	6,362	11,839	NR	--	+5.2	14.569	1	.5200	1
7-3( )80	I-Conn-Wibaux	G,GS,PMS	55	1.5	27	80.077	---	1,260	1,350	20	2,[illegible]00	686	3,228	4,406	65	85	+4.0	0.722	87	-----	.0
[illegible]( )1	Missouri R. Bridge C.	Br. Ends	42		62	1.517	---	120	875	20	1,[illegible]00	31	1,971	10,102	UC	87	+3.6	0.091	811	.0007	8
0-2( )52	Sidney N.E.	G,GS,PMS	42	5.0	20	52.569	57.569	2,270	2,000	20	6,[illegible]00	5,086	8,018	11,369	39	85	+5.2	2.048	83	.0740	2
0-2( )33	Savage-Crane	G,GS,PMS	42	9.0	20	±33.000	±42.000	1,210	3,150	20	[illegible]00	337	2,609	10,810	48	91	+5.2	0.598	68	.0430	5
0-2( )57	Fairview S.W.	G,GS,PMS	42	6.7	20	57.569	64.245	1,920	2,300	20	[illegible]00	1,020	7,960	11,369	38	86	+5.2	1.416	46	.0570	4
5-1( )46	Missouri R. Bridge WP	Br. Ends	28	0.5	25	46.539	---	1,000	1,016	20	[illegible]00	60	6,472	6,621	44	90	+3.6	1.513	25	.0630	3
5-1( )0	Circle N	G,GS,PMS	28	8.4	25	0.000	8.200	700	3,984	20	1,[illegible]00	1,060	2,226	5,692	46	91	+5.6	0.279	210	.0230	7
2-1( )0	Flowing Wells N	Resurf.	28	17.7	42	0.000	17.700	120	1,400	20	[illegible]00	20	1,085	3,762	76	95	+3.4	0.059	12	.007	9
	Sidney East	G,GS,PMS,BR	42	7.6	26	0.000	7.597	1,300	5,440 *3,440	20	[illegible]00	105	6,967	11,369	45	88	+5.4	2.569 Roy. only-2 [illegible] 10 .535 Br. only - 9 1.352 Both - 4	[illegible]	.0250	6

but Bridge

FINANCIAL DISTRICT NUMBER 4
IMPROVEMENT TYPE 7

PRIORITY	RT-#	MILEPOINT	SECTION DESCRIPTION	COUNTY	FIN DIST	YEARS BT	YEARS IM	SECTION LENGTH	WIDTH SRF	WIDTH RDY	SUF TYP	ADT	DHV	SERVICE VOLUME	SUFFICIENCY FND	SUFFICIENCY SRF	SUFFICIENCY DRN	SUFFICIENCY SAF	SUFFICIENCY CAP	SUFFICIENCY TOT	SUFFICIENCY ADJ	DEFIC MILES
1	P020	23+0.110	RICHLAND CO	RICHLAND	4	54	54	5.787	28	28	RMS	1366	177	301	0	14	10	17	21	62	60	2.2
~~0~~	~~0057~~	330+0.553	0.3 W GLENDIVE	DAWSON	4	48	50	.222	24	34	PMS	2554	306	361	6	19	8	20	17	70	64	.1
3	P042	1+0.583	MCCONE CO	MCCONE	4	60	64	6.310	24	40	BST	143	22	411	0	13	10	4	29	56	70	2.8
1	P020	18+0.596	4.2 S RICHLAND CO	DAWSON	4	54	54	4.170	28	28	RMS	1277	166	434	0	18	10	20	24	72	71	1.2
2	P042	46+0.037	10.2 S VALLEY CO	MCCONE	4	57	64	6.173	24	32	BST	130	20	724	0	10	10	5	30	59	73	2.5
2	P051	9+0.094	0.8 E DAWSON CO	DAWSON	4	55	59	9.669	28	28	PMS	234	32	371	0	13	10	11	29	63	73	3.6
2	P042	31+0.776	29.8 N MCCONE CO	MCCONE	4	56	64	5.463	24	34	BST	112	17	482	0	15	10	6	29	60	75	2.2
2	P051	18+0.776	10.5 E DAWSON CO	DAWSON	4	55	59	8.456	28	28	PMS	234	32	342	0	15	10	20	29	74	82	2.2
~~2~~	~~P057~~	330+0.150	GLENDIVE SPUR	DAWSON	4	60	60	.363	72	88	PMS	3144	377	1920	7	22	10	20	27	86	82	.1
3	P042	8+0.299	6.3 N MCCONE CO	MCCONE	4	63	64	11.418	24	42	BST	118	18	755	0	10	10	20	30	70	83	3.4
2	P042	37+0.243	35.3 N MCCONE CO	MCCONE	4	57	64	8.785	24	32	BST	113	18	482	0	12	10	20	29	71	84	2.5
			IMPROVEMENT TOTAL					66.816													34	22.7

FINANCIAL DISTRICT NUMBER 4
IMPROVEMENT TYPE 5

PRIORITY	RT-#	MILEPOINT	SECTION DESCRIPTION	COUNTY	FIN DIST	YEARS BT	YEARS IM	SECTION LENGTH	WIDTH SRF	WIDTH RDY	SUF TYP	ADT	DHV	SERVICE VOLUME	SUFFICIENCY FND	SUFFICIENCY SRF	SUFFICIENCY DRN	SUFFICIENCY SAF	SUFFICIENCY CAP	SUFFICIENCY TOT	SUFFICIENCY ADJ	DEFIC MILES
1	P062	29+0.721	4.7 S JCT FAS 201	RICHLAND	4	38	49	3.628	24	26	RMS	1247	187	387	2	16	8	3	23	52	50	1.7
1	P062	24+0.961	JCT FAS 201	RICHLAND	4	40	49	4.749	24	26	RMS	1022	153	277	0	16	8	4	22	50	50	2.4
3	P057	262+0.331	13.9 E FAP 42	MCCONE	4	47	47	5.189	24	24	BST	459	70	452	0	10	8	3	28	49	55	2.6
4	P057	256+0.590	8.0 E FAP 42	MCCONE	4	40	54	5.800	24	24	RMS	408	62	266	0	12	9	1	27	49	55	3.0
5	P057	248+0.631	JCT FAP 42	MCCONE	4	40	54	8.010	24	24	RMS	345	52	243	0	12	9	1	27	49	57	4.1
2	P057	267+0.491	JCT FAS RTE 253	MCCONE	4	41	56	10.951	24	25	RMS	553	84	515	0	8	10	14	28	60	64	4.4
			IMPROVEMENT TOTAL					38.327													47	18.2

17

Primary Bridge Replacement & Rehab.
Priority List - As of April 10, 1981

(Priorities According to Comparative Significance Rating with Sufficiency Rating Indicated)

	Feature Xed	Fin. Dist.	County Priority	S.R.	Historic Status (Group-Pg #)	Program Status	C.S.R.
1	Snowslide Gulch	1	1	02.0			78.0
1	Flathead River	1	2	19.6			66.0
1	B.N. Inc.	2	1	07.0			61.0
1	Yellowstone River	11	1	34.6			59.0
1	Sun River	6	1	42.9			57.0
1	Little Blackfoot River	8	1	08.6			56.0
1	Two Medicine Creek	2	2	22.6		P.E.	55.0
1	Blackfoot River	8	2	20.0			54.0
1	Yellowstone River	11	2	46.9			54.0
1	B.N. Inc.	11	1	62.8			54.0
1	Monture Creek	8	3	17.1			52.0
1	Little Box Elder Creek	2	1	60.8*			52.0
1	Bitterroot River	8	4	49.3			51.0
1	Missouri River	7	1	41.6		P.E.	50.0
1	B.L. & I. Canal	11	2	75.5*			50.0
1	Flower Creek	1	1	78.0*			50.0

eplacement S.R. greater than 49.9.

III. RECOMMENDED PRIORITY PROGRAMMING PROCESS

This chapter describes the recommended process to improve programming the right funds for the high priority projects. The next chapter addresses the management functions for operating the Priority Programming Process. Specific system implementation objectives relating to improved planning and programming methods are recommended.

- To improve communications between the Planning Unit, Project Control Unit, and other divisions in the Department.
- To provide a systematic means for Field Division input into Headquarter's planning.
- To establish the basis for the distribution and transfer of categorical funds among work programs.
- To identify priority planning criteria that is responsive to the needs for strategic planning.

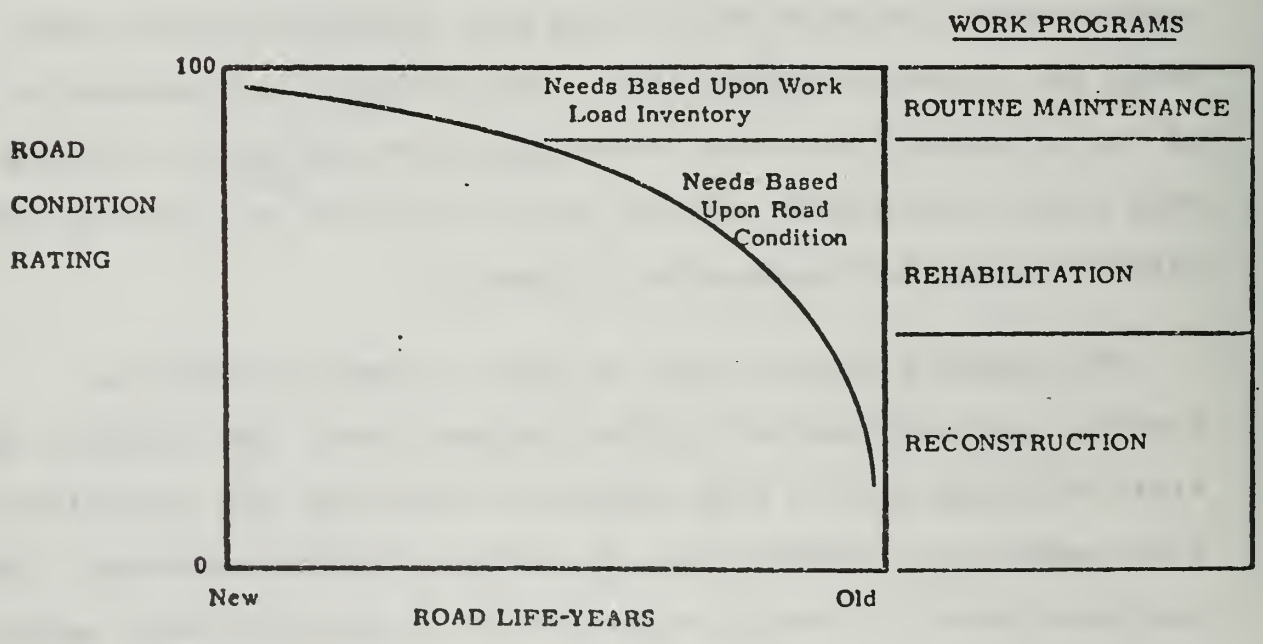
Implementation should be achieved by an initial in-depth analysis of total highway needs based upon lowered tolerable standards and a rehabilitation plan. Formalization and structuring of the management processes associated with the Priority Programming system development will be done to balance the need for both Field Division and Headquarter's planning.

The planning process must be able to address differing district and headquarter's office perspectives. For example, the Field Divisions have a high degree of visibility for rehabilitation needs but a limited view of available dollar resources. On the other hand, the headquarters office is concerned with needed program funding on the basis of limited needs visibility.

Effective planning requires developing a work plan from identified needs. The need for various work programs is dictated by two primary factors: the inventory of roadway features pertaining to: 1. maintenance work program, and 2. construction work program.

The relationship of work programs to roadway condition needs is illustrated below. In the illustration, routine maintenance needs are indicated generally by the inventory of roads that are in relatively good condition.

WORK PROGRAMS MUST BE RELATED TO DEFINABLE NEEDS



A. GENERAL CRITERIA AND OBJECTIVES

Although a prime goal of project formulation and priority arrays is to establish a common base for a work program, the total plan properly conceived could be used for added purposes. The broader objectives should include the following:

- To bridge the gap between planners, program budgeting, and the production group.
- To identify roadway condition trends as a measure of the effectiveness of current Department strategy.
- In addition to near-term two-year needs, support longer range six and twenty-year planning as a vital form for communications with the Legislature.
- To provide the capability for more effective route and system analysis.

When prioritizing needs the weights given to the project evaluation factors will depend upon the overall established reconstruction and rehabilitation strategy. This strategy will emphasize one or more of the following:

- Protection of the investment (providing added road life)
- Cost-Effective Maintenance Practices
- Roadway Utility
- User Safety
- User Comfort

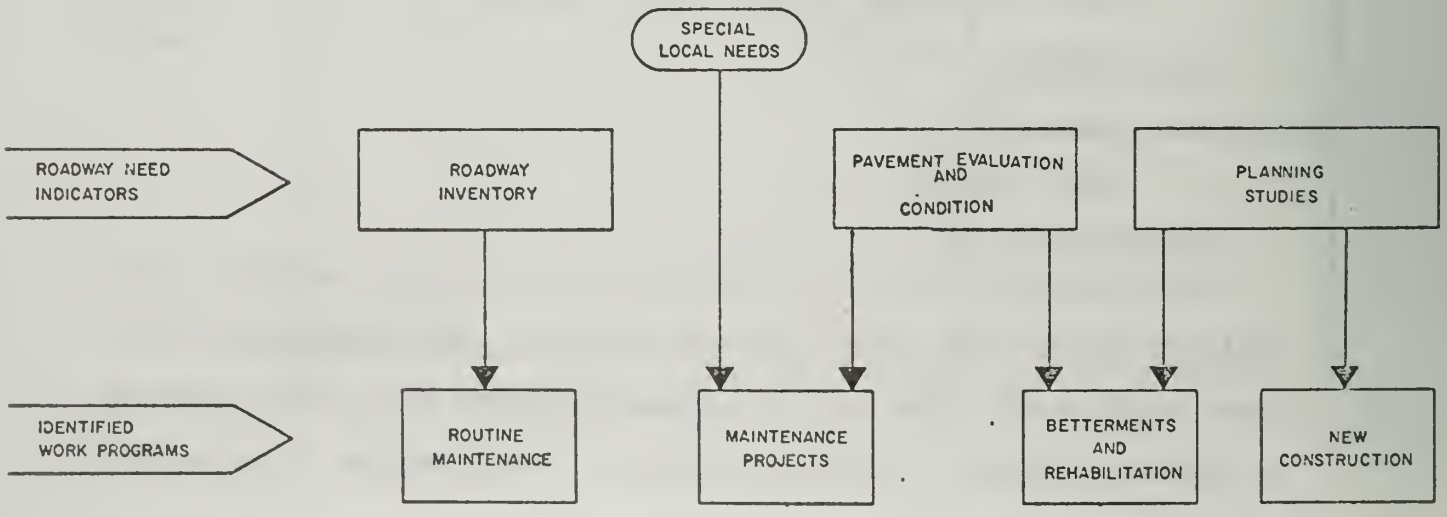
Deteriorating roads, as indicated by a formal pavement evaluation may dictate major rehabilitation. The Department must judge road conditions and determine the need for rehabilitation or reconstruction. Interdisciplinary coordination at this point

will overcome planning gaps which can occur when systems are developed solely for each individual work program.

B. EVALUATION PROCESS

Work program planning is an important initial step leading to the distribution of funds. Objectives and priorities must first be established by work program in priority arrays. Then, anticipated dollar resources are allocated among programs and financial districts based upon priorities developed from the identified needs. The exhibit below illustrates the flow of program planning information. It is important to observe the interrelationship of rehabilitation and reconstruction programs as well as maintenance.

SCHEMATIC RELATIONSHIP OF NEEDS TO WORK PROGRAM



The priority criteria as used by the computer to prepare priority lists of roadway segments within each Field Division and/or Financial District is a good starting point. Then the Field Divisions are asked to establish priorities. A priority listing could include the data for each section, for example:

- Route number
- Mile Post limits
- Control/section/job identification
- Functional roadway classification
- Number of lanes
- Estimated improvements by costs per mile
- Sufficiency rating
- Structural adequacy
- Estimated road life
- Average Daily Traffic volumes

This evaluation process is being used by the Planning and Research Bureau. For the remainder of the Department to use the process, procedural guidelines must be developed to more formalize and document the project evaluation process. The frequency of evaluation should be guided by the normal planning cycle, and budget requirements, and unscheduled events.

The guidelines must also specify organizational responsibilities and the step-by-step processes to follow through with that plan. The overall methods must be specified in detail flow to coordinate with the various levels of management who will have direct involvement with process.

C. PROJECT NEEDS DEFINITION

Project needs definition occurs in two phases. First, projects must be identified and certain preliminary project data

defined. Second, the sum of estimated costs must be re-evaluated each year. The project needs will be identified in conjunction with defining new construction, betterments, rehabilitation, and seal coating.

The list of roadway sections in priority category sequence will provide a starting point for Field Division input. Local prerogatives will sometimes influence the Field Division in selected roadway sections for project work.

The capability to define project needs will be provided technically by the Priority Programming system. The scheduling of new construction, betterments, rehabilitation, maintenance and seal-coating projects will require project definition in terms of the data elements from the Highway Information Systems File:

- Identification number
- Narrative description
- Beginning milepost
- Ending milepost
- Estimated cost
- Year of project
- Estimated life before next improvement
- Type of next improvement

The data would be provided to the Field Divisions and Headquarters by listings in various arrays and sequence. The estimated life and the type of the next improvement project will promote long-term analysis of strategies and will provide a rough measure of the cost-effectiveness of currently planned improvements.

Needs beyond fund estimates will measure identified but unsatisfied needs to assist in determining added future fund requirements.

D. BUDGET ALLOCATION

Budget allocations by the Helena Office should be on a common basis among the financial districts. The allocations for betterments and rehabilitation should be based upon the relative roadway condition and the expressed project needs as outlined below:

- Roadway Condition - The number of miles in the various priority categories will reflect the general need for betterments and rehabilitation.

  Prioritized roadway condition would be an effective base for allocation since the priority criteria will take into account such factors as ADT, functional classification (urban/rural), and pavement structure.

- Project Needs - The definition of project needs must also influence the financial district allocations. By giving weight to district requests for project dollars, the following factors will influence the amounts allocated.
  + District priorities
  + Local rehabilitation strategies
  + Differences in material costs

- Total dollar needs as expressed by each district should be moderated by the overall cost-effectiveness of proposed strategies. Cost-effectiveness can be analyzed by comparing dollars to a combination of overall roadway condition and projected improvement.

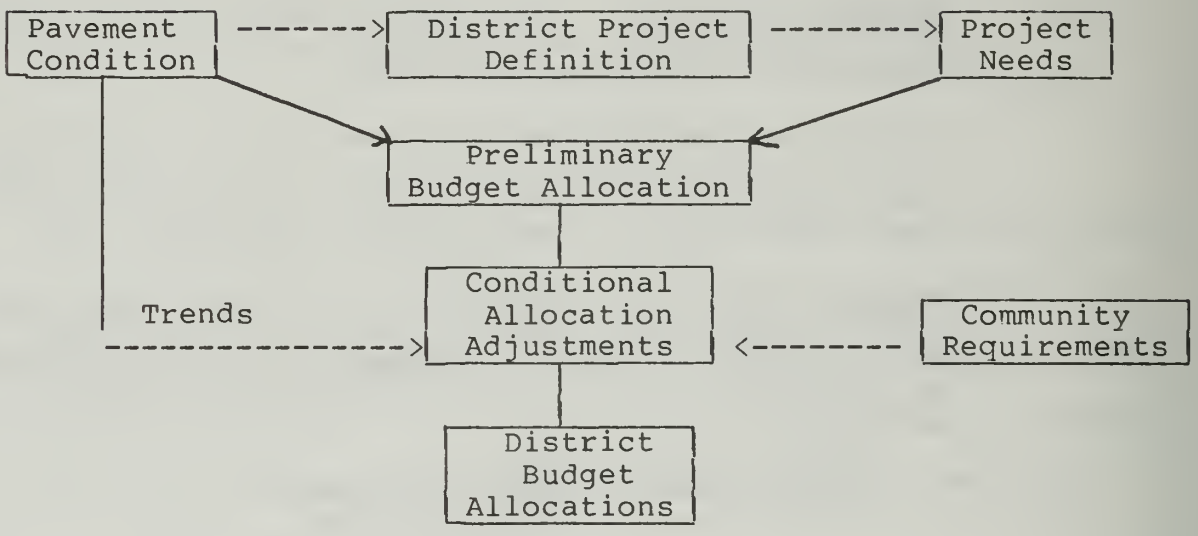
The schematic below illustrates the flow of data for budget allocation. Pavement condition and project needs are shown as the basis of a "preliminary budget allocation," - A starting point which is equitable among financial districts. The most difficult part of allocation will be finalizing based upon conditional factors such as:

- Trends in roadway condition up or down may have a bearing on the Administration's desire to apply more or less corrective resources.

- Local factors must be considered to reflect community needs.

- System-wide priorities may also be cause to adjust allocations.
- Effective management of pavement should not be penalized with lower allocations.

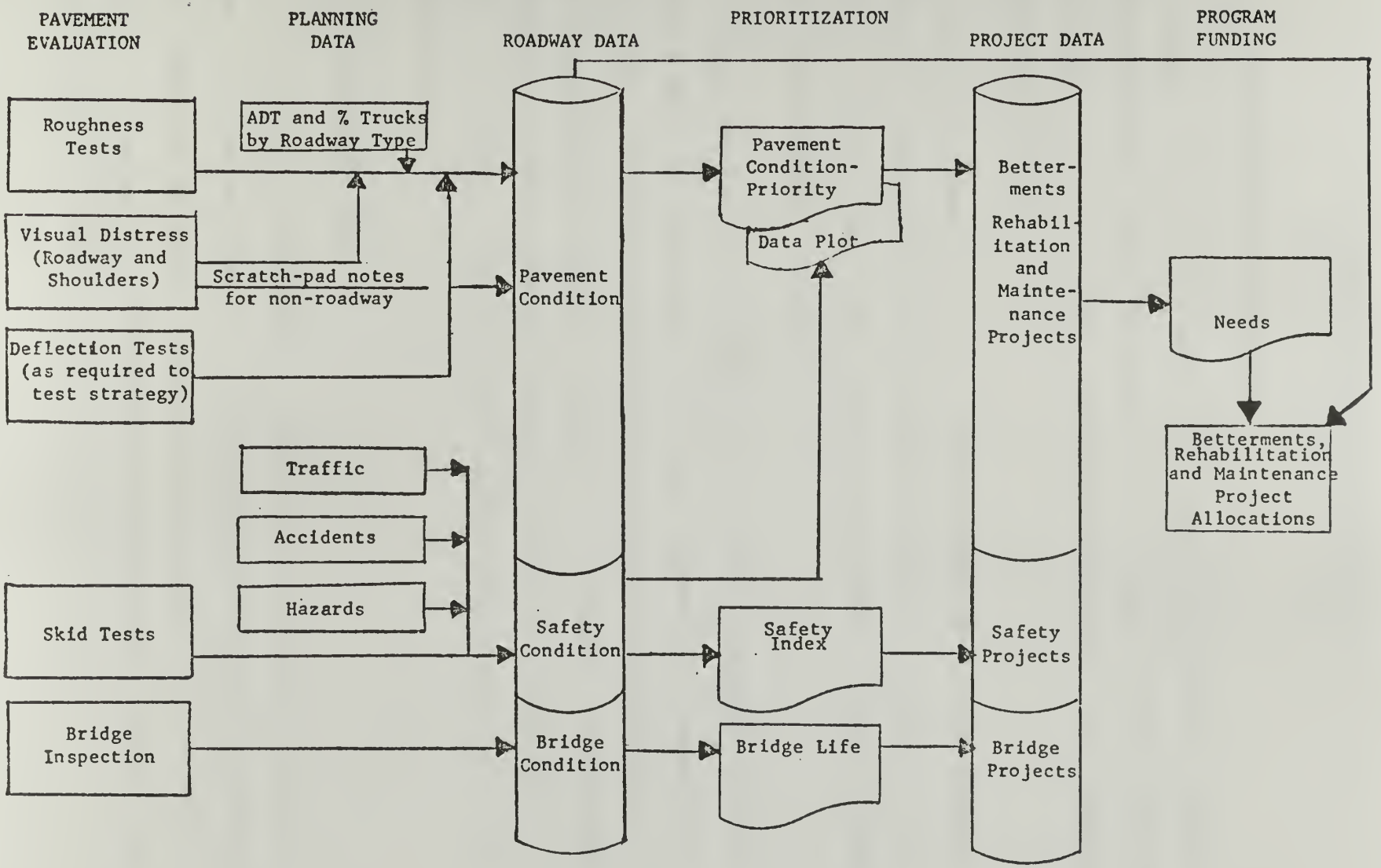
BUDGET ALLOCATION TO DISTRICTS



E. THE SYSTEM FLOW

The illustration on the following page depicts the general flow of information through the process. The process of Priority Programming includes the interrelationships of manual data gathering, HIS files, priority array reports, and manual processes to finalize each work program by district.

BETTERMENTS, REHABILITATION AND MAINTENANCE
PROJECT NEEDS DATA FLOW



R.J. Hansen Associates, Inc.

IV MANAGEMENT FUNCTIONS IN THE PRIORITY PROGRAMMING PROCESS

A. TOP MANAGEMENT TEAM CONCEPT

Project formulation, selection, and prioritization process in MDOH are of such basic importance and so inter-related with other operations that is is essential they be conducted in a formalized system environment.

This environment must use the top management team concept created by the Director to provide the overall direction and control and to assure that there is an effective decision-support type of management structure.

This team is to be made up of full-time managers, so the results will be broad based and fully support top management decisions. This affords an opportunity for the managers of all the functional processes to evaluate the effects of proposed decisions on the processes for which they are responsible. But more important, to express their inputs before decisions are finalized.

B. ANNUAL WORK PLAN

The project formulation, selection, and prioritization is made up of major kinds of recurring decisions so it is essential that there be an annual work plan and schedule for decision making. Otherwise, some important decisions are likely to be overlooked, or deferred until there is a crisis.

The example on the following page illustrates the kind of work plan envisaged.

A step-by-step top management decision process needs to be developed and implemented so that it requires a high degree of participation by middle-management and operating managers.

BASIC ELEMENTS OF ANNUAL WORK PLAN FOR TOP MANAGEMENT

(EXAMPLE ONLY)

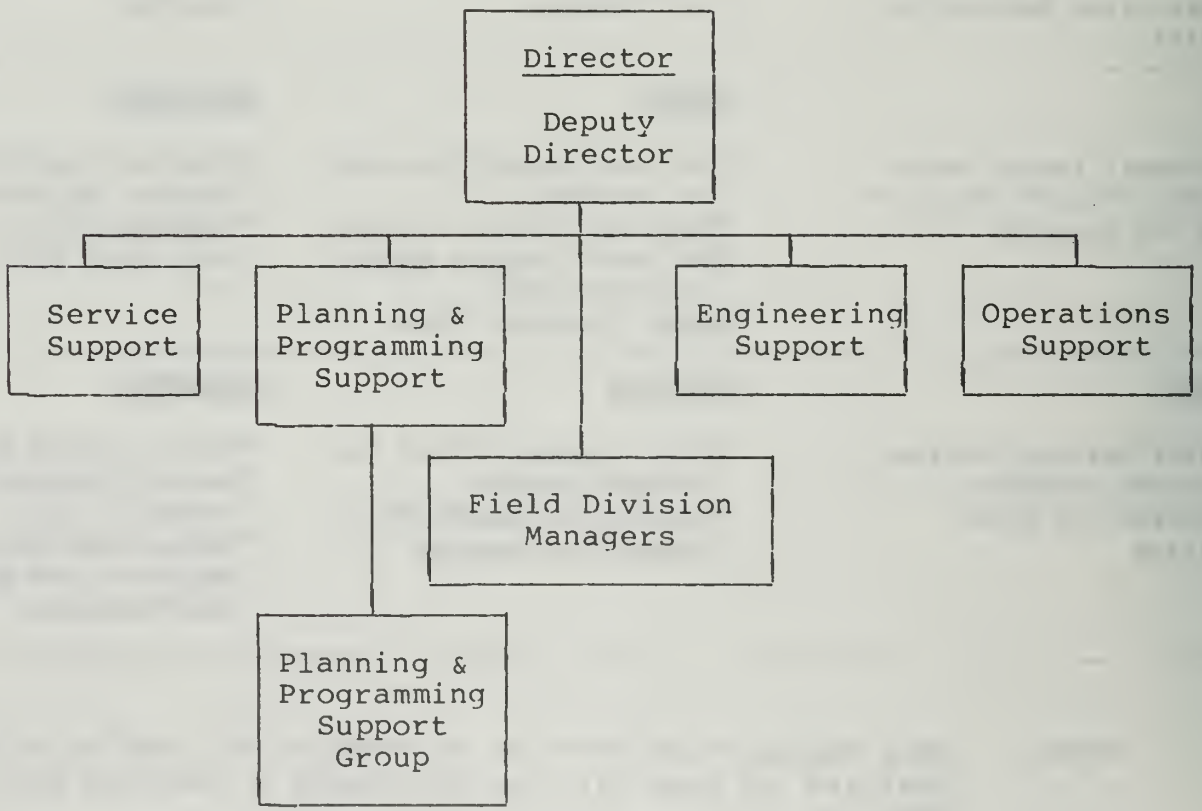
JANUARY	FEBRUARY	MARCH
°Set MDOH Goals and Overall Objectives for Next Year °For Five Years °Set Improvement Priorities, Policies and Standards °Review Last Year's Production Performance °Set Program Development Guides	°Legislative Response and Strategies. °Review Actual Receipts vs. Project and Revenues °Schedule Major Policy Changes	°Review and Analize Planning and Research Program and Modify or Approve °Legislative Response °Review Program Progress
APRIL	**MAY**	**JUNE**
°Review Maintenance and Operations Program and Plan °Financial Review °Review Technology transfer Plan °Review Value Engineering Results	°Review Construction Program - Add one year to it °Review Legislative Program Results -- Set Guidelines for Legislative Program Next Session	°Review Administrative and Engineering Support Program Plans for Construction and Maintenance Program °Review current program progress
JULY	**AUGUST**	**SEPTEMBER**
°Semi-Annual Fiscal Review °Consider Resource Requirements for Programs	°Internal Budget Hearings and Proposals °Finalize Budget Decisions °Set Annual Report Guidelines/Policies °Adopt Financial Plan	°Finalize Legislative Program and Strategies °Finalize Budget and Review with State Officials
OCTOBER	**NOVEMBER**	**DECEMBER**
°Review/Finalize External Relations Programs °Review/Decide Major Policies	°Total Program Review for Accomplishments °Pinpoint Strengths/Weaknesses/Shortcomings	°Review Annual Report °Review Finances and Financial Plan °Define Preliminary Objective for Next Year/Biennium

NOTE: This Annual Work Plan is an example only and must be modified to best fit the Department's required work plan.

C. PLANNING AND PROGRAMMING GROUP

To formalize the priority programming process and to make the best use of the top management team described above, the Department must organize a Planning and Programming support group complete with necessary policies, standards, and selection criteria. There must also be a disciplined adherence to the priority programming process and adequate opportunity from top management to review progress by top management.

The group would include the Planning and Research Bureau, Priority Programming Section, and an advance planning group as well as the Secondary Roads Unit. This unit would represent the Planning Support function as shown below.



Some of the functions and responsibilities of the planning and programming support group would be:

- To maintain a continuing strategic plan.
- Coordinate public knowledge and involvement in projects as they progress through the Priority Programming Process.
- Promote and maintain a long term analysis of strategies that would provide a continuing measure of the cost-effectiveness of currently planned improvements.
- Coordinate the project selection and project formulation process with each Field Division.
- Keep current the various listings and arrays such as:
  - † Two and Six Year Needs - the two and six year needs for betterment, rehabilitation, and new construction projects will be represented by the sum of all projects scheduled by year.
  - † Project Lists - will identify individual projects grouped by program by year. The lists would be similar in format to the current program project listings. A variation could be produced by location for route analysis.
  - † Cost Summary - listings will array program costs by year allowing the analysis and adjustment of needs estimates over the next six years. Where total costs are high or low compared to estimates of available funds, projects can be rescheduled or rehabilitation strategies can be revised. The smoothing of costs can be in interactive process using the financial planning and preconstruction system, if developed, until a realistic projection of six year needs is reached.
- To perform the budget allocation process for the Financial Districts based upon priority needs.
- To develop and communicate basic policies, standards and criteria in highway system planning and to implement an effective system and procedures for regularly reviewing and evaluating results of program operations.
- To develop a process which evaluates and appraises actual results in relation to planned results -- to provide a basis for control by top management.

- To develop and implement the recommended Pavement Management System which would provide additional road life measurements and priority arrays for improvements.

- Develop support data for the highway construction program needs and maintenance betterments for the Legislative funding recommendations.

V. RECOMMENDED PLAN OF ACTION

From the findings outlined, the recommended need for a Priority Programming Process, and changes of organizational structure, it is recommended that a task force be formed to put these processes into motion.

VI. BENEFITS TO BE GAINED

+ A well conceived program

+ Public acceptance of Construction Program

+ Better distribution of work load

+ Well balanced Department

+ Distribution of funds based upon documented and prioritized needs

+ Documented support for budgetary request for Legislative action

+ Public involvement in the selection process

+ Better cost-effective product

RJH:nr:207E

R.J. HANSEN ASSOCIATES, INC.

MANAGEMENT AND INFORMATION SYSTEMS CONSULTANTS

PAVEMENT

MANAGEMENT INFORMATION NEEDS ANALYSIS

FOR THE

DEPARTMENT OF HIGHWAY
STATE OF MONTANA

July 1981

Draft Final
July 27, 1981

FINAL REPORT

CONCEPTUAL DESIGN
for a
PAVEMENT MANAGEMENT SYSTEM

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

Prepared by
R. J. HANSEN ASSOCIATES, INC.
July, 1981

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I. INTRODUCTION

Study Background and Objectives

In response to recognized needs for a Pavement Management System, the Department has set out to (1) evaluate current practices, (2) define a framework of concepts for improved systems and procedures, and (3) identify the basic information needs and organizational structure to effect the improvements for this system.

The major information needs in this system are to:

† Provide adequate data to set priorities.

† To help formulate a work program.

† Include structural adequacies for analysis.

† Provide road life information and future needs.

The study was identified as a Phase One Needs Study, to be followed by subsequent phases of more detailed system designs, developments and implementations.

This report covers the findings and recommendations to Pavement Management.

This report could not have been completed without the valuable participation and assistance of the Departments' Pavement Management Steering Committee throughout the period of this study.

Overview of Pavement Management

The concept of a comprehensive Pavement Management System (PMS) is relatively new in highway agencies. Many of the elements of PMS are routinely performed by most highway agencies. But seldom are they found as a formal, comprehensive system which provides decision makers with optimum strategies through clearly established rational procedures. Wrong decisions relative to pavement design and periodic rehabilitation, resurfacing and maintenance can be costly. It is generally accepted that signif-

cant economic benefits can be realized through an effective PMS.

The need for PMS is further emphasized by recognized changes in the characteristics of typical highway improvements nationwide. Nearly all state highway agencies predict that the 1980's will be a period of less major new construction and greater attention to 3-R projects (Resurfacing, Restoration and Rehabilitation). Such work is directed principally to assuring continuing structural integrity and adequate levels of rideability for pavement surfaces, sometimes accompanied by other minor improvements. Numerous alternative approaches usually are available. PMS can help identify those which are most cost effective.

SUMMARY OF RECOMMENDATIONS

† That there be top management commitments to the development, implementation and on-going use of a Pavement Management System.

† The system should be directed to the Planning and Programming levels of the Department responsible for formulating, prioritizing and budgeting work programs and to the technical levels for the appropriate inputs into the decision making process.

† The system must be kept as simple as possible.

† The data used must be fully integrated with the Highway Information System (HIS).

† Organize a Pavement Management Group in the near future to review on-going processes and recommend a plan for developing a Pavement Management System.

II. SUMMARY OF FINDINGS AND CONCLUSIONS

The first step of the study was to identify, review and evaluate those current activities of the Department that were related to the general subject of Pavement Management.

Pavement-Related Work Operations

The Department currently carries out several types of work operations directly related to pavement surfaces. All would be involved in someway with the proposed pavement management system.

- New Construction and Major Reconstruction -- This activity involves the design and construction of highway projects on new locations, or on existing locations where little or any of the existing roadway can be salvaged.

  Decisions on programming these types of projects usually are made on the basis of evaluations of the geometric adequacy of the existing roadway -- items such as lane width, shoulder width, alignment, grades, sight distance, etc. The priority of such projects may be influenced by the adequacy or inadequacy of the existing roadway surface. The principal relationship to pavement management is in the criteria and procedures used in the design of new pavements.

- Rehabilitation -- These projects usually are less complex than new construction or major construction. Most of the existing roadway is salvaged. Some minor work may be included for improvement of alignment, grades, roadway width and drainage. And, some upgrading of the base and subbase may be included to assure adequate foundation for a new surface.

- Resurfacing and Restoration -- These projects commonly are referred to as "overlays". The work usually involves iso-

lated patching, repair of soft spots, leveling to remove undulations, and placement of a new surfacing course -- all within the limits of the existing surface. Seldom is other work included except for improvement of traffic control and traffic safety features.

·Maintenance Seal Coating -- This work consists of application of bituminous material and aggregate cover course to an existing roadway surface. It serves two purposes: (1) to seal the surface and prevent roadbed deterioration caused by penetration of surface water, and (2) to improve the skid resistance qualities of the surface. It does not increase the load bearing quality of a pavement. Proper scheduling and performance of the work is an essential part of pavement management.

·Seal Coat Policy -- Many years ago seal coating was a standard practice for pavements that had been in service a number of years. The seal coats extended the pavement life, were inexpensive and were done with federal aid.

In the opinion of the committee, seal coating is not currently being performed to the extent necessary to meet design strategies. This contributes to premature deterioration and failure of the flexible pavements throughout the state. There are a number of contributing factors supporting this opinion. They are:

(1) The Federal Highway Administration considers seal coating and similar surface treatments that are less than 3/4" thick a maintenance activity and not eligible for Federal Aid except for those seal coats that are incorporated in the original design. The current pavement design practice expects a seal coat after 7 years, an overlay at year 13 and another seal coat at year 20 as a pavement life cycle management

strategy. (2) Seal coating has not been a program of high priority for cost-effective management of the pavement during its life therefore seal coating has had to compete with other activities for funds remaining after the major programs for the construction and maintenance. (3) In about 1963 the FHWA decided that the Departments Type 3 plant mix bituminous surfacing was sufficiently dense that they do not need seals. In about 1974 that situation reversed so that seals were again made part of the design. However, there are many miles in those 10+ years that have never been sealed. (4) A Highway Commission audit in 1968 identified a serious need to better manage the gravel stockpiles owned by the department. Legislative audits in subsequent years also mention the departments investment in gravel stockpiles. Since the 1968 audit, the department has reduced its gravel inventory markedly. There has been some reluctance to plan a stockpile program for future seal coat operations because of the possible adverse attention it may attract.

·Routine Surface Maintenance -- This work consists of regular day-to-day operations of repairing isolated pavement deficiencies -- activities such as patching potholes, filling surface cracks, repairing edge raveling, etc. -- all directed to assuring adequate pavement performance between periodic projects of resurfacing or reconstruction.

Obviously, this work is important to the pavement management effort. Considerable savings can be realized if the work is properly scheduled and performed, and if the time periods between more expensive resurfacing and rehabilitation projects can be lengthened.

Formulation of Work Programs

Detailed discussions of current practices of the Department

for formulating work programs are presented in separate reports entitled "Project Formulation, Selection and Priority" and "Maintenance Management". Discussions in this report are related principally to pavement related decision making.

·Major Work -- Projects of new construction or major reconstruction are considered major work. The adequacy of the existing pavement is but one of many factors considered in the selection of major projects for construction programs.

The headquarters level has principal responsibility for formulating programs of major work. Although such programs regularly are developed by the Department, there is no clearly defined and documented procedure for the rational selection of projects.

Most major projects are designed by the headquarters staff or by consultants. Some Division Offices occasionally design major projects. All major projects are constructed by contract.

Criteria and procedures for pavement design are discussed in a following section.

·Overlays -- This category includes simple resurfacing, sometimes accompanied with other rehabilitation work. As is the case with major work, there is no evidence of any standard formal procedures for formulating programs of overlay projects. However, there appears to be a considerable degree of informal coordination between the headquarters level and field maintenance and construction levels in the matter of selecting projects. But, the lack of formalized criteria and procedures for identifying the most appropriate cost effective type of improvement for particular conditions has lead

to misunderstanding and differences of personal opinion.

Design of overlay work occurs at both the headquarters and division levels. Pavement thicknesses are designed by a headquarters unit. Most overlay work is let to contract. Some short sections of road mix overlays are performed by maintenance forces and are identified as a maintenance operation.

·Maintenance -- Pavement related maintenance work consists mainly of regular routine surface maintenance and periodic seal coating. Current practices for programming of maintenance are presented in the separate report on Maintenance Management.

Generally speaking, the planning, programming and scheduling of pavement maintenance is a responsibility of the Division field maintenance level -- within a general framework of guidance and direction by the headquarters Maintenance Bureau.

Pavement Information Sources

Several existing information sources are used, in varying degrees, to help decision-making related to pavement work programs. The various information sources are described below.

·Sufficiency Ratings -- The Department carries out a program of annual sufficiency ratings of Primary Highways. Data are collected on the geometric characteristics and surface conditions of the various road sections. Evaluations are made to define the degree of sufficiency of the following items:

+ Foundation (10 pts.)
+ Surface (30 pts.)
+ Drainage (10 pts.)
+ Safety (20 pts.)

+ Capacity (30 pts.)

A completely adequate section would be rated at 100 points. Ratings are adjusted to reflect traffic volumes thus giving additional priority to sections carrying above-average traffic volumes.

The rating system is generally consistent with that used by many highway agencies. Of the 100 potential points, 40 points influence the pavement. It is this portion of the rating that is pertinent to pavement management. The data is tied in to the Department's total Highway Information System (HIS).

A brief review of the rating system shows both good points, as well as some questionable characteristics. For a considerable number of years, the ratings have been compiled by one or two individuals in the Planning and Research Bureau. This has promoted consistency, both throughout the state and throughout the years. On the other hand, the condition ratings are mostly of a subjective nature reflecting judgements of the raters. The lack of physical measurements of pavement deficiencies tends to lessen the credibility of condition ratings.

The sufficiency ratings are limited to Primary highways. Interstate routes and Secondary highways on the State system are not currently rated.

Although sufficiency ratings regularly are referred to in the development of improvement programs, here are no formally established criteria as to how the ratings shall be used.

·Skid Resistance -- About ten years ago the Department began a program of pavement surface skid resistance measurements for all Interstate highways, all Primary highways and some Secondary highways. The program is safety-related and is

meant to identify those sections where treatment is needed to improve the skid resistance characteristics. Such information is pertinent to PMS.

The program continues on a five or six year cycle of complete measurements, with intermediate selective measurements to update data on sections which have been resurfaced or resealed. The information is available in the Department's HIS. Some information in the system may be as much as five or six years old.

The equipment and instrumentation currently used for the measurements are quite sensitive and subject to frequent breakdown. In a recent year, a record of 50% down-time was experienced.

It is questionable whether current practices can produce the type of timely skid resistance information needed for regular comprehensive evaluations related to pavement management.

·Traffic Data -- The Department regularly carries out annual programs of collection and analysis of traffic data on all Federal-Aid systems. Information is collected for both volumes of traffic and composition of traffic. All data is incorporated in the Department's HIS.

Current practices appear to satisfy the traffic-data needs of pavement management for evaluating existing pavements and for designing new pavements.

·Accident Data -- Accident data regularly is incorporated in the HIS for Federal-Aid Systems. Such information is essential for the evaluation of the overall adequacy of road sections -- particularly as related to the geometric elements. The data also can contribute to pavement evaluations by helping to identify those locations where pavement deficien-

cies (lack of skid resistance, etc.) may contribute to accidents.

Other Information Needs

Investigations clearly show that currently there are little, if any, capabilities for objectively measuring the extent of pavement deficiencies. Pavement condition ratings are selected for individual sections after visually inspecting the various deficiencies. By itself, numerical value developed by this process, does not tell the whole story. Proper corrective actions usually are dictated by both the type and extent of deterioration. Comprehensive pavement management practices rely on having this information available.

Various types of equipment now are available for quantitative measurement of factors such as rideability and deflection. The desirability of some of these techniques will be discussed in a subsequent section which presents recommendations.

Pavement Design Practices

Policies, criteria and procedures for pavement design are documented in the Department's "Surfacing Design Manual". Design is based on AASHTO Interim Design Procedures using the "R" value method to determine surfacing thicknesses. This approach is generally accepted. It is noted that several changes in the manual are anticipated later this year.

Current design practices for new flexible pavements assume a future seal coat in the seventh year after construction, an overlay in the thirteenth year, and another seal coat in the twentieth year. It is the judgement of the committee that the service life of many sections of flexible pavement has been greatly shortened by a lack of adherence to the prescribed frequency for regular seal coating.

Basic responsibility for pavement design is placed in the

Preconstruction Bureau. This unit relies heavily on traffic data from the Planning and Research Bureau, soils and materials information from the Field Divisions and the Materials Bureau, and coordination with the field Divisions.

The relationships among these various units does not appear to be clearly defined. Numerous examples have been described showing a lack of effective communication and mutual understanding. Recommendations of maintenance personnel often are not adequately received and considered.

It was the general consensus of the Pavement Management Users Committee that the Materials Bureau probably should have more involvement in pavement design throughout the project development period and that research should play a larger role. The committee feels that design criteria have not kept pace with the trend of increasing weight of tracks -- as evidenced by considerable more rutting of surfaces in recent years. They expressed the thought that there should be periodic review of the design criteria.

Conclusions

Based on the findings described in the preceding sections, the consultant and the Steering Committee arrived at the following conclusions which are particularly significant.

1. The Department currently is performing many of the individual functions which normally would be integral parts of a pavement management system -- but there is no established procedure or criteria defining how this information is to be used. As a consequence, most of the decisions on selection of improvement projects are based on the subjective judgments of individuals.
2. Current practices for compiling highway sufficiency ratings provide a reasonable measure of the overall adequacy of individual road sections -- but, in its present form the

system does not provide the types of information needed for realistic evaluations related to pavement management. Often the ratings can be misleading, particularly if attention is directed only to the total ratings rather than the components that make up the ratings. And, the components are not adequately detailed or documented to tell the whole story.

3. Currently there are no assurances for cost-effective investments as related to (a) selection of projects, (b) types of improvements, and (c) priorities of needed improvements.

4. There is no basis for identifying long-range improvement needs required to assure acceptable levels of pavement service. Measures of trends of pavement serviceability do not exist.

5. Significant deterioration of pavement surfaces and shortening of pavement life have occurred because prescribed seal coat practices have not been followed.

6. There is critical need to develop and implement systematic procedures for cost-effective management of pavements -- to be closely integrated with an overall planning and programming function of the Department. Such a system is recommended in the following section.

III. RECOMMENDED PAVEMENT MANAGEMENT

Within the scope and time frame of the current study it cannot be expected to develop all the details of processes for pavement management. The intent is to conceive a framework of basic policies, criteria and procedures to guide those who subsequently will design and implement a pavement management system specifically adapted to the needs of the Department.

Basic Objectives

To assure uniform understanding among all those individuals involved in developing and implementing a pavement management system, the following statement of objectives is recommended:

The Pavement Management System shall provide (1) timely, factual information, (2) formal processes for evaluations, and (3) criteria for decision-making -- all directed to assuring the most cost-effective actions for work programs of:

1. Construction of new pavements
2. Resurfacing, restoration and rehabilitation of existing pavements, and
3. Maintenance of pavements.

General Criteria

The following general criteria should be adhered to by those who conceive and develop the systems and procedures:

1. The system should be directed to the administrative levels responsible for formulating, prioritizing and budgeting of work programs -- and, to the technical levels where decisions are made on pavement design, monitoring of existing pavements, and appropriate maintenance operations and procedures.
2. The system must be kept as simple as possible, involving the collection and processing of only that data essential to operation of the system.

FRAMEWORK FOR PAVEMENT MANAGEMENT

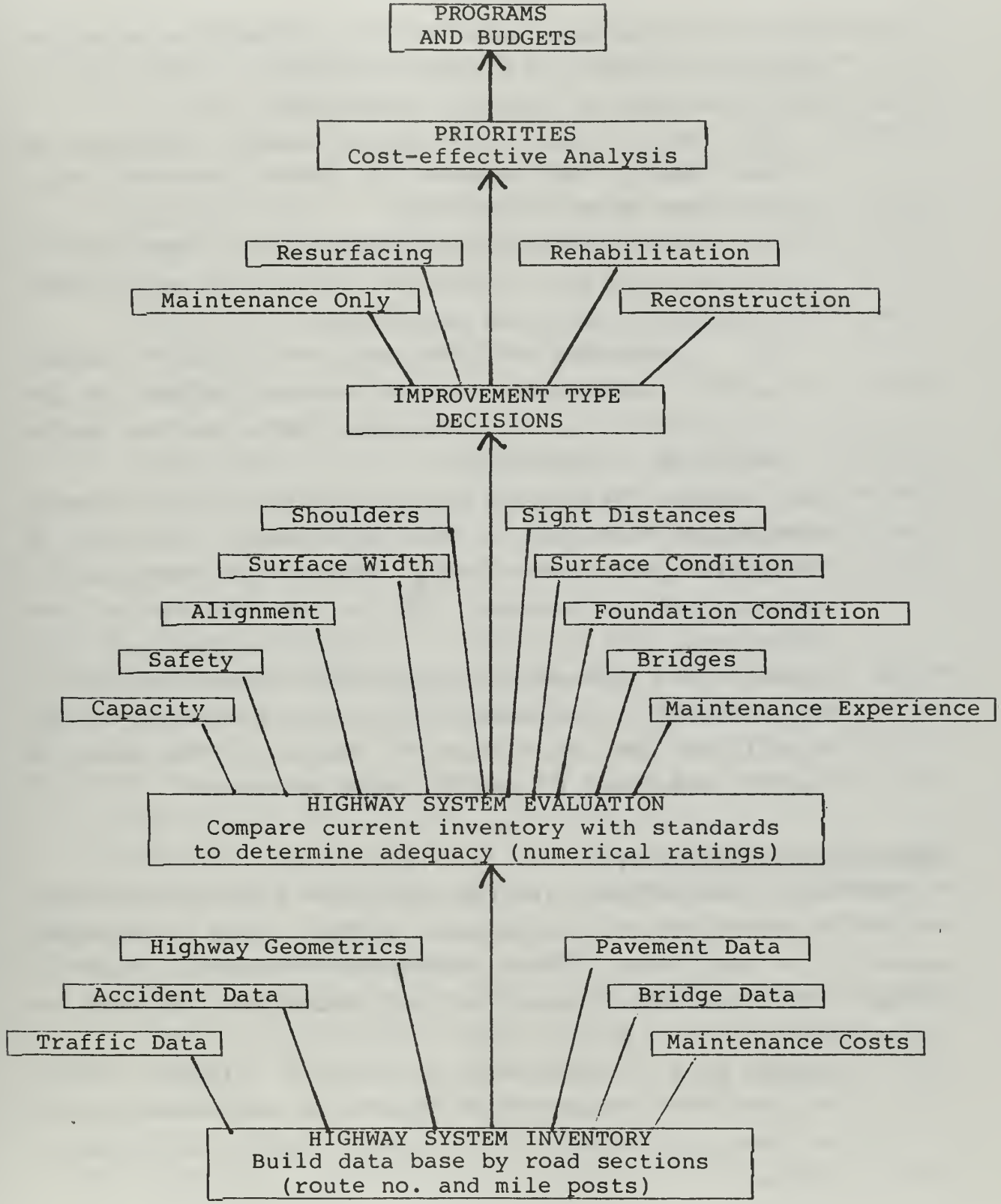

Figure 1

3. The data to be used must be fully integrated with the Department's existing Highway Information System (HIS).
4. The system must be fully supported with:
   (a) a system flow chart clearly showing the steps to take place, the sequence of events and the relationships among the events;
   (b) a comprehensive procedural manual with detailed instructions for the actions along with established criteria for decision making, and;
   (c) a program of orientation and training to assure uniform understanding of the system, as well as the responsibilities and procedures for effective implementation and operation.
5. The Pavement Management System can not be a separate independent function of the Department. It must be integrated with and closely support the Department's planning and programming efforts for construction and maintenance work programs.
6. Concepts and procedures for pavement management should be generally in accordance with the framework of the simplified flow chart shown in Figure 1. The chart is further described in the following sections.

Highway System Inventory

Meaningful and reliable information is the key starting point for an effective pavement management system. Much information currently is available. Some additional information will be needed. The basic requirements for individual road sections are indicated below:

1. Traffic Data - Information on traffic volumes (current and projected average daily traffic), and information on the characteristics of the traffic (numbers and types of trucks).

2. Accident Data - Comprehensive data on the history of traffic accidents within the limits of the road section.
3. Highway Geometrics - Information on horizontal and vertical alignment, number of lanes, lane width, shoulder type and width, and sight distance restrictions.
4. Pavement Data - Information on pavement type, surface condition, foundation condition and types of deficiencies -- supported as required by physical measurements of skid resistance, roughness, and deflections, using modern equipment developed for this purpose.
5. Bridge Data - Information on bridge dimensions, clearances and condition.
6. Maintenance Costs - Information on maintenance costs by road sections can be helpful in evaluations if the basic information is reliable. The validity of current maintenance cost data by sections in Montana is questionable.

Highway System Evaluations

Regular periodic evaluations of the total highway system should be made every one or two years by comparing current inventory information with the standards and criteria determined desirable for the various classes of roads and prevailing traffic conditions.

Evaluations would be made of all major elements of the roadway in terms of a numerical rating that reflects the degree of adequacy of each element in relation to desireable standards. Elements to be evaluated should include:

1. Traffic Capacity - The ability to safely and conveniently carry the volumes of traffic using the road section.
2. Safety - Analysis of accident data to identify those hazardous road sections where accident rates are abnormally high.
3. Alignment - Both horizontal and vertical alignment should

be evaluated and rated in terms of adequacy.

4. Surface Width - The width of the paved surface provided for through traffic.
5. Shoulders - The type of shoulder (paved or unpaved) and the width of shoulder are important considerations.
6. Sight Distances - Restrictions in stopping sight distances and passing opportunities on road sections should be evaluated.
7. Surface Conditions - The types of deficiencies and the physical measurements of roughness will provide an objective rating of surface condition.
8. Foundation Condition - Physical measurements of deflection and rutting will reflect the adequacy of foundation materials with a numerical rating.
9. Bridges - Bridge adequacy should be evaluated to assure that roadway improvements will be coordinated with bridge replacement work that may occur in the near future.
10. Maintenance Experience - This is an optional evaluation. It is meaningless unless current data is reliable. Ratings might be related to above normal costs.

All of the above evaluations can readily be made using computer programs. With appropriate guidelines and criteria in the program, the computer can scan the inventory data and determine the appropriate rating values.

Improvement Type Decisions

By evaluating and rating the various elements of each road section, the types and extent of deficiencies can be pinpointed. This, in turn, will guide decisions on the most appropriate type of improvement proposed (if any).

For each rated element, a rating value would be identified which is considered "acceptable". Ratings below that level would be "unacceptable". The most appropriate type of improvement for

a particular section would depend on the ratings for various combinations of roadway elements. For example:

1. For any road section on which all elements were rated acceptable or better, no improvement would be proposed. This does not mean the section is up to "desireable" standards -- but we are willing to live with it for the time being, and can get by with maintenance operations and periodic resealing.
2. For road sections with "unacceptable" ratings in alignment, sight distances or capacity, the proposed improvement normally would be new construction or major reconstruction.
3. When surface and/or foundation ratings are unacceptable, accompanied by unacceptable ratings in surface width, shoulders or safety, rehabilitation work should be designated.
4. When surface condition is unacceptable, but all other elements are acceptable, a resurfacing overlay or seal and cover would be called for.

The computer can be programmed to analyze the ratings of the various combinations of elements of a road section and make preliminary determination as to the most appropriate type of improvement. All preliminary determinations should be reviewed to consider any unusual conditions which might dictate an alternative type of improvement.

Establishing Priorities

The total current improvement needs will be identified following evaluation of the road sections and determination of types of improvement. Priorities for undertaking these improvements normally should be guided by the rating values. Road sections with the lowest ratings should be first priority.

But, this is not always true. The principal criteria for

priorities should be the cost-effectiveness of the investment. Analysis of estimated costs and benefits should be the final step in structuring the order of priorities.

Programs and Budgets

Two options are open with regard to programs and budgets. If it is clear that the amount of available funds for a program period is relatively fixed, the improvement program would be comprised of projects from the priority listing selected down to a priority level where all of the estimated available funds would be committed.

However, if the potential funding for the period is not rigidly fixed, alternative improvement programs and budget requirement should be considered -- with clear documentation of the specific accomplishments expected from the various levels of funding.

Final approval of proposed improvement programs and budge requests should be a function of top management -- with appropriate consideration of information, evaluations and recommendations provided by the pavement management system and the planning and programming processes.

Formulation of programs and budgets for pavement maintenance is discussed in a separate report on Maintenance Management.

Standards for 3-R Projects

A basic concept of the 3-R Program (resurfacing, restoration and rehabilitation) is that cost-effective improvements can be realized without resorting to totally new construction or reconstruction. But, it is recognized that usually it may be necessary to accept a compromise in the geometric standards to be used.

Projects of the 3-R category should salvage as much of the existing roadway as possible. Application of "new construction

standards" makes this difficult, and often the proposed improvement is no longer cost-effective.

To facilitate the 3-R Program (which has great signifcance to pavement management) the Department should formulate and adopt a multi-tiered approach to design standards based on types of construction. Separate tables of desirable and minimum standards might be established for

Lower levels of geometric standards (lane width, shoulder width, slopes, lateral clearances, etc.) would be permitted with the less extensive types of construction. Higher standards would be encouraged when costs would not be greatly affected, but absolute minimum standards would be defined. In addition to "type of construction", the conventional factors of traffic, road class and terrain should be considered in establishing values.

Forecasting Future Needs

The PMS should be designed to permit realistic forecasting of future needs for continuing pavement improvement programs. This would include analysis of the effect of various levels of improvement programs on pavement conditions throughout the total system. And, it should be able to predict the expected surface life of individual pavement sections, as related to surface type, design criteria, traffic volumes, traffic composition characteristics and climatic conditions. The intent is to provide a basis for long-range forecasting of needs as a guide for identifying the scope and magnitude of annual work programs of pavement improvements.

Alternative Programs

As a basis for realistic evalutations by top management and by those responsible for legislative review of budget requests, alternative programs should be formulated defining various levels of annual work effort and corresponding financial requirements.

Such alternatives should clearly define the specific work to be performed -- and the long-range affect of the alternative programs on the rate of overcoming accumulated pavement deficiencies and upgrading the pavement serviceability of the total highway network.

Examples of alternative pavement improvement programs, and their effect, are shown in Figures 2 thru 5. These are extracted from a report by the Materials Office of the Washington State Department of Transportation.

Figure 2 shows a 6-year "dream" program without financial restraint. The results are quick and dramatic -- but, the costs are prohibitive.

Figure 3 shows a modest program, possibly a continuation of present practice. The average pavement condition rating would continue to decline during the 6-year period.

Figure 4 represents a slightly larger and more costly program -- but it would assure a gradual upgrading of the average pavement conditions over the program period.

The effect of the alternative programs on the yearly average pavement condition ratings is illustrated graphically in Figure 5. Other options may be proposed. The point is that this type of information should be available to decision makers as a part of the total pavement management process.

PAVEMENT IMPROVEMENT PROGRAM

"DREAM BUDGET"

	PAVEMENT CONDITION RATING			
YEAR	BEFORE	AFTER	MILEAGE % AFFECTED	COST*
1981	53.1	88.6	46%	$ 62,752,668
1982	83.6	87.6	8%	11,758,111
1983	83.3	86.4	5%	6,624,903
1984	81.4	83.4	4%	5,661,168
1985	77.2	81.9	8%	14,155,899
1986	75.4	83.1	15%	33,893,546
				$134,846,295

6-YR AVG RATING = 80.4

*ALL COSTS ARE INFLATED COSTS

Figure 2

PAVEMENT IMPROVEMENT PROGRAM

BUDGET #1

YEAR	PAVEMENT CONDITION RATING BEFORE	AFTER	MILEAGE % AFFECTED	COST
1981	53.1	59.3	7%	$ 9,050,095
1982	52.3	57.4	7%	9,048,675
1983	51.2	57.5	7%	10,299,085
1984	51.7	56.1	6%	10,300,148
1985	50.5	52.8	3%	9,449,439
1986	47.4	49.7	4%	9,449,286
				$ 57,596,728

6-YR AVG RATING = 53.2

Figure 3

PAVEMENT IMPROVEMENT PROGRAM

BUDGET #2

YEAR	PAVEMENT CONDITION RATING BEFORE	AFTER	MILEAGE % AFFECTED	COST
1981	53.1	62.0	11%	$ 12,349,188
1982	55.4	61.9	8%	12,349,691
1983	55.9	63.3	9%	14,949,463
1984	57.6	63.4	7%	14,949,477
1985	58.0	65.0	9%	17,954,686
1986	59.7	64.6	8%	17,952,927
				$ 90,050,432

6-YR AVG RATING = 60.0

Figure 4

ALTERNATIVE PAVEMENT IMPROVEMENT PROGRAMS

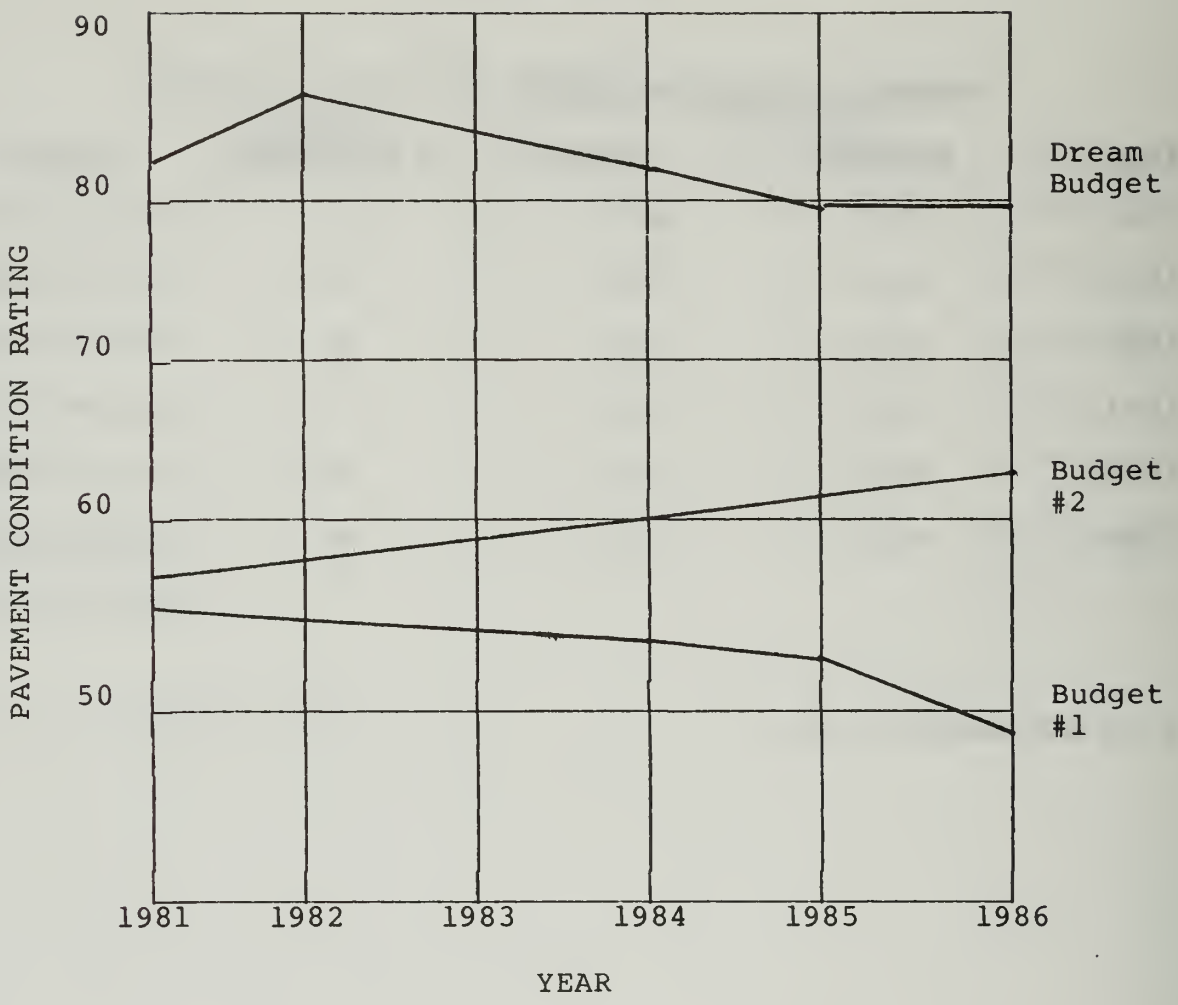

Figure 5

IV. ORGANIZATION CONSIDERATIONS

A pavement management function currently does not exist in the Department within the context of a comprehensive systems approach. This section discusses some of the factors which should be considered in the organizational placement of the function.

Functions and Responsibilities

The basic work functions related to pavement management are described in the previous sections of this report. Responsibilities for carrying out individual elements of the major functions are found in various existing organizational units, including:

1. Planning and Research Bureau;
2. Preconstruction Bureau;
3. Materials Bureau;
4. Field Construction Bureau
5. Field Maintenance Bureaus;
6. Data Processing Bureau; and
7. Accounting Bureau.

Most of the basic information is provided by Planning and Research. The Preconstruction Bureau and the Materials Bureau are jointly involved in the technical aspects of pavement design. The Field Maintenance and Construction Bureaus participate in the selection and prioritizing of projects. Basic information is processed and summarized by the Data Processing Bureau. And, the basic responsibility for budgeting lies with the Accounting Bureau.

Because there is no formalized, systematic approach to pavement management, no single organizational unit has been assigned responsibility to ensure that the function is being carried out effectively. Probably, the Planning and Research Bureau comes closest to acting as a program coordinator --although their role is not clearly spelled out.

Coordination of Programs

It would be a mistake to attempt to categorize PMS and the related pavement improvement projects as a separate entity with separate responsibilities. There should not be a separate Pavement Management Bureau or Section. Rather, the concepts and procedures of pavement management should be routinely incorporated in the functions of the organizational units charged with the responsibilities for developing maintenance programs and the comprehensive construction programs.

Basic Responsibilities

This study recognizes a critical need for (1) expanding the overall planning function of the Department, (2) defining the systems, procedures and responsibilities for planning and programming, and (3) developing the capabilities for carrying out the functions.

It is conceived that there might be a Division (or Bureau) of Planning and Programming, and that the responsibilities of construction-related pavement management (resurfacing, restoration, and rehabilitation) be assigned to this unit. Formalized relationships should be established between this unit for input, review and approvals by Field Maintenance Bureaus and by the headquarters Maintenance Division.

Responsibilities for carrying out the maintenance-related portions of the pavement management system should be assigned to the headquarters Maintenance Division, with formalized procedures for coordinating with the Field Maintenance Bureaus and the headquarters Planning and Programming Division.

Pavement Design

With increased emphasis on 3-R projects, resulting in more projects directed principally to pavement rehabilitation, it may be desirable to transfer basic responsibilities for pavement

design from the Preconstruction Bureau to the Materials Bureau. Most of the basic information needs for pavement design are developed by the Materials Bureau. This alternative should be explored.

V. DEVELOPMENT AND IMPLEMENTATION

The concepts and recommendations presented in this report provide only the basic framework management system for the Department. This section provides guidelines for system development and for effective implementation of the system.

General Approach

Several alternative approaches might be considered for the development and implementation of improved systems.

1. Retain the services of an experienced consultant team to perform most of the required system design -- in coordination with a Department Steering Committee; or
2. Retain the services of an experienced individual consultant to act as a team leader working with a small task force of Department personnel assigned full-time to the work; or
3. Undertake the design and implementation entirely with Department personnel, led by an individual who would be earmarked to continue to head the organizational unit.

The first alternative should facilitate the design and implementation in a shorter period of time.

The third alternative may take a considerably longer period of time unless the Department individual selected to head the undertaking is very familiar with modern planning and pavement management technology.

The second alternative may be a reasonable compromise with an experienced individual consultant directing the work.

The legislative mandate of HB 500 that the improved management systems be operational by July 1, 1985, makes time an important consideration.

Project Definition

The areas defined in this study as "Project Formulation,

Selection and Priority" and "Pavement Management" are so closely tied together that it does not seem realistic or practical to involve two separate consultants or two separate Department task forces. The two should be combined. In effect, the effort would be directed to a total comprehensive Planning and Programming function, in which PMS would serve as an effective tool for decision making. It is suggested that the Phase II work be identified as the "Planning and Programming Project".

Development Plan

A proposed plan for development and implementation is illustrated in Figure 6. It is flexible as to the extent of involvement of consultants.

The chart in Figure 6 is self-explanatory. After the initial organization for the project, the plan provides for periods of:

- System Development
- Pilot Testing
- Statewide Implementation, and
- Continuing Review and Improvement.

Consultant involvement would be most beneficial during the periods of development, pilot testing and initial implementation. With extensive consultant assistance, it is estimated that the system design can be accomplished in a period of nine to twelve months and that the pilot testing would require an additional four to six months. And it would be helpful if the consultant was available for the first three or four months of the initial implementation.

It is difficult to estimate time requirements for the various phases if the work is undertaken solely with Department personnel. Probably, the period for design and development would be considerably longer.

Solicitations for consultant services should clearly set forth the ground rules for the scope of work by the consultant

PAVEMENT MANAGEMENT SYSTEM
PLAN FOR DEVELOPMENT AND IMPLEMENTATION

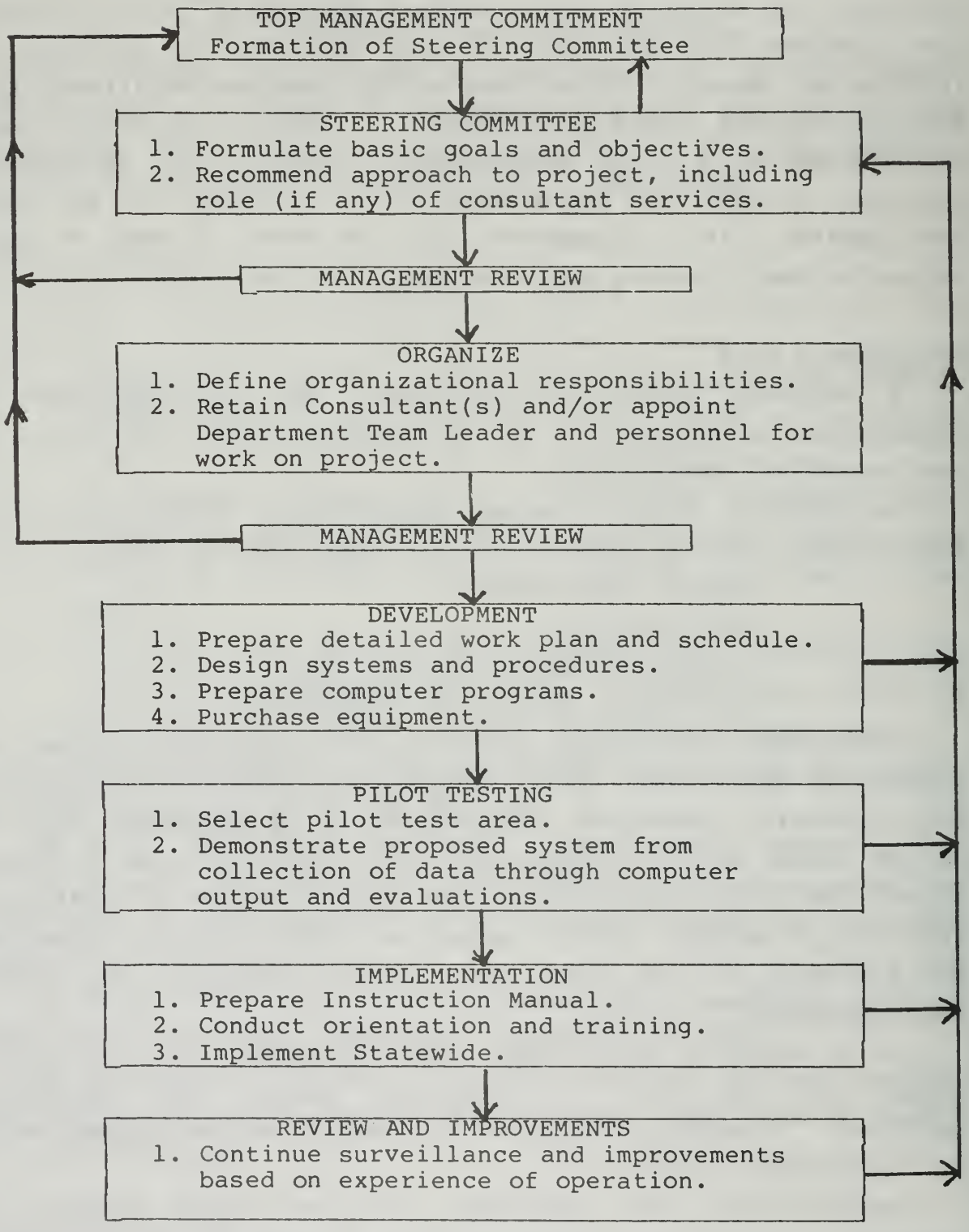
TOP MANAGEMENT COMMITMENT
Formation of Steering Committee
STEERING COMMITTEE
1. Formulate basic goals and objectives.
2. Recommend approach to project, including role (if any) of consultant services.
MANAGEMENT REVIEW
ORGANIZE
1. Define organizational responsibilities.
2. Retain Consultant(s) and/or appoint Department Team Leader and personnel for work on project.
MANAGEMENT REVIEW
DEVELOPMENT
1. Prepare detailed work plan and schedule.
2. Design systems and procedures.
3. Prepare computer programs.
4. Purchase equipment.
PILOT TESTING
1. Select pilot test area.
2. Demonstrate proposed system from collection of data through computer output and evaluations.
IMPLEMENTATION
1. Prepare Instruction Manual.
2. Conduct orientation and training.
3. Implement Statewide.
REVIEW AND IMPROVEMENTS
1. Continue surveillance and improvements based on experience of operation.

Figure 6

and by the Department -- as well as the general characteristics of the systems desired by the Department. The basic criteria and framework for management systems recommended in this report should be included in consultant solicitations.

Development Costs

Costs of development and implementation are limited to man days and the costs of personal services. Travel costs and other miscellaneous costs are not included.

This estimate would limit consultant involvement to guidance, direction and supervision for about 18 months.

	Est. Man Days	Est. Cost
Consultant Personnel	300	$ 70,000
Department Personnel	1,700	240,000
Total	2,100	$310,000

The above estimate should be considered as only a "rough" preliminary estimate and principally indicatives the scope of work and costs that might be expected.

Some additional costs can be anticipated for system operations, including expenditures for equipment that may be determined most appropriate for physical measurement of pavement conditions. Since much of the needed data collection currently is being performed by the Department, additional personnel requirements for operations will be of a minor nature.

Benefits

Normally, a proposal for new procedures and for investments should be supported by assurances that the potential benefits will substantially exceed the investment costs. In this case it is virtually impossible to quantify the adverse affect of some current practices or the benefits to be expected from improved pavement management.

The real question is whether the Department has a realistic

basis for assuring accountability for the preparation and carrying out of improvement programs with cost-effective expenditures. Right now it doesn't. The recommended systems for planning, programming and pavement management will provide those capabilities.

Preservation of the investment in pavements by lengthening the pavement surface life will be a principal economic benefit. But, equally important as the potential economic benefits are the benefits of improved Department communication and relationships with the Legislature and the general public, as a result of improved practices.

DP:BH:snk:213E

R.J. HANSEN ASSOCIATES, INC.

MANAGEMENT AND INFORMATION SYSTEMS CONSULTANTS

FISCAL PLANNING AND CASH FORCASTING

MANAGEMENT INFORMATION NEEDS ANALYSIS

FOR THE

DEPARTMENT OF HIGHWAY
STATE OF MONTANA

July 1981

FINAL REPORT

CASH FORECASTING MANAGEMENT INFORMATION SYSTEM SYSTEM FEASIBILITY STUDY

STATE OF MONTANA

DEPARTMENT OF HIGHWAYS

July, 1981

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INTRODUCTION

1. Project Background and Objectives

The Montana Department of Highways has engaged the firm of R.J. Hansen Associates, Inc., to assist in preparing a study for the purpose of

> "identifying the overall organizational and management information needs for the Department and planning to meet these needs".

This report covers the findings and recommendations in the area of Fiscal Planning and Cash Forecasting.

The purpose of a Cash Forecasting Management Information System is to provide the Department with the capability of estimating its cash position in the future. Knowledge of funding levels, obligations, revenues and available funds consolidated into a single cash position forecast will assist the Department in:

+ Evaluating project priorities based on available funds
+ Planning construction letting schedules
+ Developing the Department's budget
+ Minimizing cash reserves
+ Substantiating funding level requirements
+ Communicating project status.

It is the intent of this report to provide a detailed analysis of the Department's needs, together with a methodology and development plan for the establishment of a Cash Forecasting System.

R. J. Hansen Associates wishes to acknowledge the excellent support and co-operation provided by the Department's staff during

this project, particularly the Steering Committee for Fiscal Planning and Cash Forecasting. We would also like to thank the Department's Word Processing Bureau and, in particular, Pegge Zander, for their tireless efforts on behalf of the project.

2. Summary of Recommendations

It is the consensus of the Steering Committee that the Department implement a Cash Forecasting System in the following manner:

1) Develop a manual system immediately (Alternative I).
   + This would meet the Department's needs for the short-term and would be the most rapidly available.
   + The training and implementation effort would be adaptable to the creation of an automated system.
   + It can be created entirely in-house.
   + The estimated costs are:

Development	$ 24,000
Annual Operation	$ 37,500/yr.

2) Develop an automated system as soon as possible.
   + The restrictions and limitations of the manual system make an automated system a necessity.
   + If a total Project Management System is to be developed, Cash Forecasting should be included (Alternative III). The estimated share of the total costs are:

Development	$183,000
Annual Operation	$ 29,500/yr.

   + If no Project Management System is to be developed, the Cash Forecasting System should be constructed as a stand-alone

automated system (Alternative II). The estimated costs of this alternative are:

Development	$198,000
Annual Operation	$ 36,500/yr.

The automated system which will eventually be created will provide the following benefits:

+ An accurate and timely overview of the Department's fiscal status.
+ The capability to inquire directly into the status of a particular project.
+ A tool by which management can pursue a sound Fiscal Planning policy and minimize cash reserves.
+ A communications medium through which all sections of the Department can be made aware of the current and proposed construction programs.
+ A mechanism through which changes in funding, scheduling, project scope or resource commitment can be simulated and the results evaluated.
+ Development of a detailed budget will be highly simplified.
+ Evidence of inadequate revenues will be demonstrable. This will allow the Department to support requests for fuel and other tax adjustments based on the current highway needs analysis and the estimated cost of the construction program.

II. Summary of Findings

The findings are divided into an overview of the subject, current Department policies, identified problems and needs, and the objectives and considerations of developing a system.

1. Overview of Fiscal Planning and Cash Forecasting

Fiscal Planning and Cash Forecasting are two very distinct, but very interrelated entities. Fiscal Planning is a management process. It is that function of management by which the financial status of the Department is predicted, planned for, controlled and acted upon. It is the key element for all of the Department's planning processes.

Cash Forecasting, however, is a tool rather than a function of management. It is the mechanism which predicts the flow of cash into and out of the Department. But it is this tool which is the cornerstone of a sound Fiscal Planning process.

During the "boom times" of the sixties, most Highway Departments were able to charge ahead with their construction programs secure in the knowledge that there was always enough cash to cover their activities. Since then, however, the rock-solid ground on which they stood has been shaken by soaring inflation, wild fluctuations in Federal apportionments, changing laws at both the Federal and State levels, and changes in the traditional State funding picture.

As a result, many states are now creating cash flow and forecasting systems to support their Fiscal Planning policies. They

are recognizing that a good Fiscal Planning process supported by a sound cash forecasting system will allow them to:

+ Evaluate project priorities based on the forecasted cash position
+ Plan construction letting schedules
+ Budget accurately
+ Plan maintenance expenditures
+ Obtain the most productive use of their available funds
+ Monitor ongoing projects
+ Minimize cash reserves.

These needs, which are also present in the Montana Highway Department, have changed many State Highway Departments to a new direction; one which is characterized by a sound fiscal policy supported by a Cash Forecasting System.

As an example of this, on June 30, 1981 at the WASHTO Convention, Eugene L. Rowen, Secretary of Transportation for the State of South Dakota, described his Department's "Cash Flow Forecasting System". He stated "at an expenditure rate of over 7 million dollars per 2 week pay period, our Department went to a $16,000 low balance point last construction season. Without this tool of forecasting cash flow, this would not have been possible." He also said, ". . . I feel every state must tighten up their cash forecasting methods to better utilize the small amount of cash they have. The public demands this type of management in times of high interest rates."

2. Current Fiscal Planning Policies

Current fiscal planning practices within the Montana Highway Department have generally been informal and primarily oriented toward development of the budget. Cash forecasting, such as it was, existed as scattered mechanisms performed by various individuals with very little co-ordination or intercommunication. This created the situation where the various sections could not be certain at any given time if the projects they were working on would ultimately be funded. The problems were further compounded when changes were made in the scope or construction schedules of projects and these changes were not communicated to the other interested sections. Further, the Department was unable to present an accurate and timely picture of its current fiscal status.

3. Needs of the Department

Along with the problems identified above, the Department finds itself facing perhaps its most trying times. Like many other government entities, it has entered a period characterized by:

+ Revenues which do not keep pace with inflation
+ Increasing expenditures
+ Closer scrutiny by the public as well as by other government agencies
+ Greater demands for service
+ Pressures to increase productivity - to produce more for each tax dollar
+ Uncertain Federal and State financing.

These are all items which, in past times, had not been of significant concern to State Highway Departments.

Specifically, the Department has the following needs which require the creation of an accurate Cash Forecasting Management Information System.

+ Preparation of the Department's budget - a Cash Forecasting System would be invaluable in this area. The capability for simulation, particularly on the Preconstruction and Construction segments, would allow the Department to apportion its funds internally to the best advantage.
+ Program Fund Management - Federal Aid fund programs are becoming increasingly more complex. The various factors such as specific regulations for fund usage, administrative Federal agency, transferability of funds, time frames to obligate funds before they are subject to lapsing and lengthening lead times all must be carefully weighed so as to obtain the maximum amount of benefit from available Federal funds. By allowing various alternative proposed construction programs to be examined through the use of its simulation capability, a Cash Forecasting System would be the key tool by which these fund programs would be managed.
+ Minimizing Cash Reserves - again the proper management of available funds, through a Cash Forecasting System, would allow cash reserves to be reduced to their lowest practicable level as was done in South Dakota.
+ Verification of the Fundability of Projects - A sound Forecasting System would alleviate the situation of projects

being started without any certainty that they would, in fact, be fundable after the completion of design.

+ Support of Funding Level Requirements - we are in a period in which the public is strongly questioning much of the current tax structure and, in particular, any proposed increases. The Legislature is understandably wary of imposing any such increases without adequate evidence of need. A Cash Forecasting System would allow the Department to project its fiscal requirements, based on maintaining a specific level of service in the construction and maintenance of the state's highway system. The Legislature would then be able to responsibly assess the necessity for tax adjustments as opposed to a reduction in the Department's level of service.

4. System Development Considerations

Objectives

Regardless of what mechanism is used to implement a Cash Forecasting System, the objectives of the system should include the following elements:

+ The system should have the capability of providing short range forecasts of high accuracy. These forecasts should be in the neighborhood of 2 3/4 to 3 years into the future so as to accommodate the budgetary process.
+ The system should be able to make long range forecasts of at least 5 years into the future with reasonable accuracy based on current conditions.

+ The system should have a substantial degree of flexibility, particularly in regard to reporting, the inclusion of all revenues (existing and proposed) and the inclusion of all expenditures (existing and proposed).
+ The system should be able to compensate for uncontrollable variables such as inflation.
+ The system should not be overly sophisticated. In such a highly speculative area, the value of excess sophistication is questionable. The system should use a simple, straightforward but flexible method of performing its projections. An example of such a method would be the forecasting curves developed by other states for their own use.
+ The system should be "Department wide". All sections of the Department should have access to the system and its data so that the information about projects, schedules and funding is available to all. This will reduce the problem of lack of communication.
+ The system should be controlled by the following in developing project forecasts:

    Type and size of project
    Location (geography)
    Estimated cost
    Estimated letting date (including seasonal considerations)
    Estimated duration of the project

+ The system should be able to provide simulation forecasts based on such variables as:

Adding/removing/rescheduling projects

Lengthening/shortening projects

Changes in funding, including new sources

Changes in resource commitment

The necessity for this capability was underscored by Mr. Rowan, Secretary of Transportation for the state of South Dakota, in his presentation of their Cash Forecasting System. He identified only four problems with their current system but one of these was:

"We are unable to provide the 'what if' answers".

+ The system should allow data from unfunded projects to be included without a letting date but with a dated estimate for use in simulation reports.
+ The system should be able to provide estimated revenue figures that can be used as input into the State Budgeting and Accounting System. Likewise, the actual revenue and expenditure figures output by SBAS should be able to be entered into the Cash Forecasting System.
+ As the system ages it should be able to provide reports showing the "actual vs estimated" history and should allow the control variables to be modified accordingly.
+ The reporting mechanism for the system should allow for flexible reports to be created at both the summary and detail levels.
+ The detail level reports should be able to match the level of detail which had been input for a particular project.

+ The summary level reports should show breakdowns of projects by:

  - Fund
  - Phase of work
  - System
  - Financial district
  - Project

5. Methodology

The successful development of a Cash Forecasting Management Information System will depend primarily on the methods chosen to create the projections. These can range from simple straight line interpolations to complex linear regression or other statistical techniques. It is recommended, however, that the Department follow the example of several other states which have or are developing such systems. This would entail the creation of forecasting "curves" based on past trends.

For revenues, the curve for each non-Federal category could be fairly simple. For example, Exhibit I shows the breakdown of all non-Federal income over the past five years together with the percentage of the Department's total revenue which this represents. Exhibit II shows the same data graphically for the top five categories and the total. It is apparent that despite the confusion of recent years, most of these individual items display an approximately linear trend. The forecasting of non-Federal revenue then could be limited to an analysis of these key items. In fact, as shown in Exhibit III, the top three items represent an average

of 92% of the total. By projecting these three alone (which could be done easily because of their linearity) and dividing by 0.92, a reasonably accurate estimate of the total non-Federal revenues for the year could be made. The accuracy could be further improved if mineral royalties and miscellaneous revenues were included, but these do not appear to be as consistent as the others.

EXHIBIT I

NON-FEDERAL REVENUE

Fiscal Year	1976	1977	1978	1979	1980
Gasoline	32,723,069	34,551,943	36,843,719	37,603,226	39,319,259
GVW & Related	11,746,134	13,415,540	16,101,362	16,660,845	17,407,726
Diesel	7,914,517	8,787,176	9,443,204	9,906,542	10,787,516
Mineral Royalties	2,243,054	3,642,103	2,656,923	2,821,194	3,087,744
Miscellaneous	1,230,317	478,041	2,188,696	1,266,426	2,599,321
Fuel Trip Permits	537,327	607,565	646,184	281,090	741,230
Size & Weight Fees	270,941	343,627	389,320	409,705	465,271
Special Fuel, etc.	20,990	40,011	44,569	38,586	19,727
Custom Combiner's	25,455	31,275	26,865	24,555	19,575
Total	56,711,804	61,897,281	68,340,842	69,012,169	74,447,369
PERCENTAGE OF TOTAL HIGHWAY DEPT. REVENUE	44%	38%	44%	47%	36%

NOTE: The above table excludes coal tax receipts since it is no longer a revenue source for the Department.

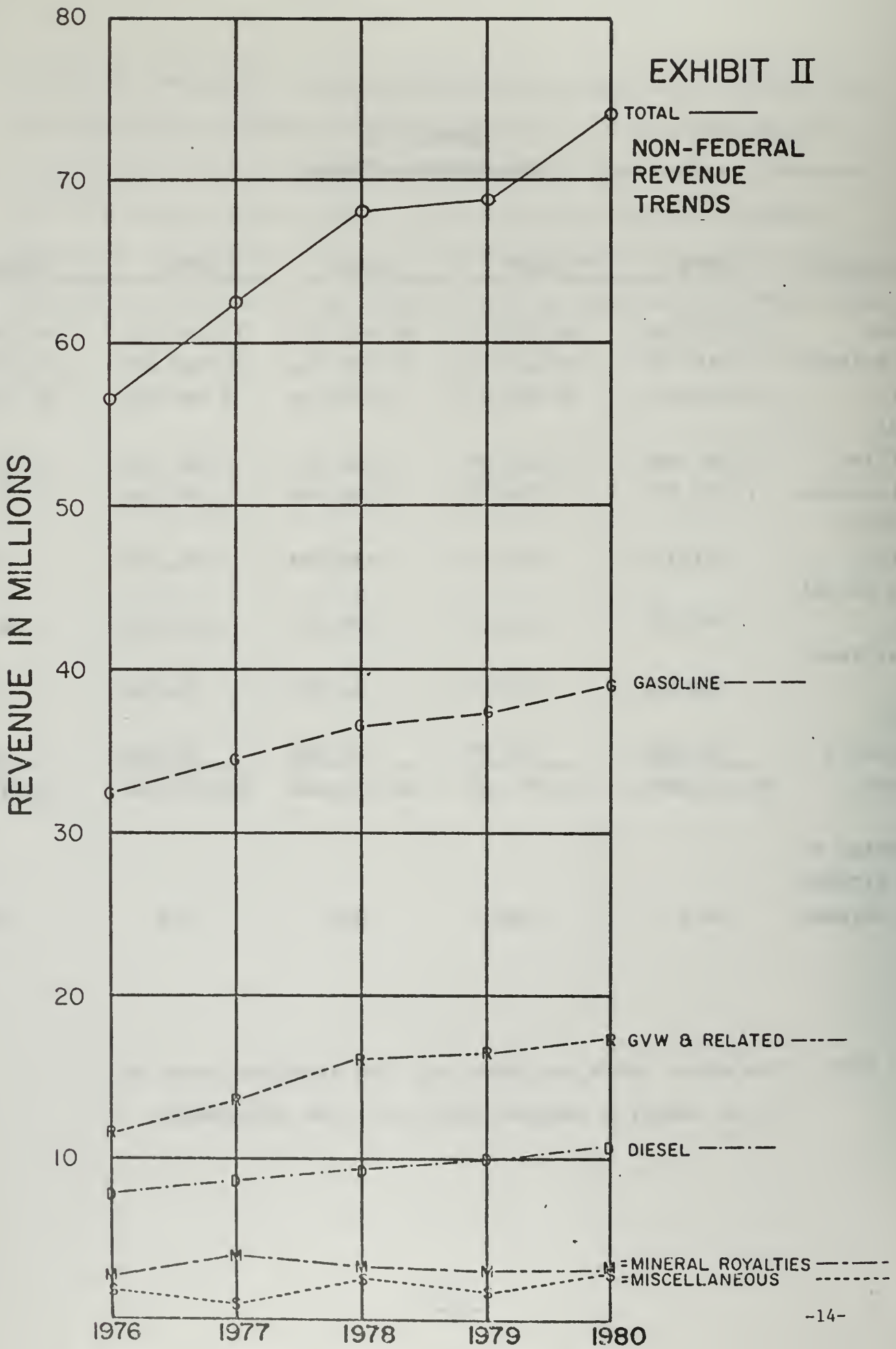


EXHIBIT II
NON-FEDERAL REVENUE TRENDS
REVENUE IN MILLIONS
80
70
60
50
40
30
20
10
1976
1977
1978
1979
1980
TOTAL
GASOLINE
GVW & RELATED
DIESEL
=MINERAL ROYALTIES
=MISCELLANEOUS

EXHIBIT III

PERCENTAGES OF TOTAL NON-FEDERAL REVENUE

Fiscal Year	1976		1977		1978		1979		1980	
	TOTAL	%	TOTAL	%	TOTAL	%	TOTAL	%	TOTAL	%
Gasoline & GVW & Diesel	52,383,720	92%	56,754,659	92%	62,388,285	91%	64,170,613	93%	67,514,501	91%
Above & Mineral Royalties	54,626,774	96%	60,396,762	98%	65,045,208	95%	66,991,807	97%	70,602,245	95%
Above & Miscellaneous	55,857,091	98%	60,874,803	98%	67,233,904	98%	68,258,233	99%	73,201,566	98%

In order to refine the yearly estimates down to a monthly level, an analysis should be made of the monthly trends during prior years. This would allow the establishment of a "seasonal" curve for each of the major categories. Monthly revenues could then be calcualted by applying this curve to the estimated annual figure.

Federal revenues, which represent a larger share of the Department's income, show less consistency over the past five years.

Fiscal Year	1976	1977	1978	1979	1980
TOTAL FEDERAL REVENUE	72,664,083	102,960,296	87,461,008	76,538,752	132,448,356
PERCENTAGE OF TOTAL HIGHWAY DEPT. REVENUE	56%	62%	56%	53%	63%

However, the process of estimating this revenue is simplified since it is tied directly to those projects being developed by the Department which are eligible for Federal funds. By estimating the expenditures on those projects (see below) and applying the correct participation percentage for the appropriate activity, projections of the Federal Aid billings can be made. Payments by the Federal Government can safely be assumed to occur within the next month following the billings. Thus the mechanism which is used to forecast the expenditures relating to the develop-

ment of projects can also be used to predict the revenues which will accrue.

The forecasting of expenditures should be made for both program and non-program types. The trends for non-program expenditures over the past five years is shown on Exhibit IV. Several conclusions can immediately be drawn from this exhibit.

+ Since it consistently represents less than 10% of the Department's total expenditures, forecasting techniques for these areas need not be overly sophisticated. Any errors in the individual projections would have little impact on the overall expenditure forecast.
+ The largest single item (City-County Construction) is fixed by state law to a minimum of $6,650,000. It is increased only if excess fuel tax revenues are received. The excess can be estimated as part of the overall fuel tax revenue projection.
+ A group of items which together represent the second largest expenditure in this area consist of charges made by the Highway Patrol, the Department of Revenue, and Highway Traffic Safety Office. Since the amounts designated for these other agencies are set by the Legislature rather than by the Department, projections of future levels will have to be made in conjunction with personnel from these offices. However, this should not cause great difficulty.
+ Although the remaining items fluctuate more widely, their basis is well known and easily calculable.

EXHIBIT IV

NON-PROGRAM EXPENDITURES

Fiscal Year	1976	1977	1978	1979	1980
Highway Patrol	3,022,503	3,191,681	3,648,834	3,704,528	7,456,090
Dept. of Revenue	359,941	388,966	429,395	441,101	476,531
Highway Safety	42,046	39,535	91,678	72,705	54,142
City-County Construction	7,374,211	7,444,492	7,011,274	6,813,863	7,313,114
Buildings	262,303	54,372	118,612	354,679	894,546
Hwy. Complex	-0-	1,239,300	550,000	548,000	-0-
Equipment Depreciation	-0-	1,088,815	1,751,369	1,160,439	881,721
Total	11,061,004	13,447,161	13,601,162	13,095,315	17,076,144
PERCENTAGE OF TOTAL HIGHWAY DEPARTMENT EXPENDITURES	8%	8%	9%	9%	8%

The remaining expenditure area includes those items which are classified by programs. These programs are General Operations, Construction, Maintenance, Preconstruction, Motor Pool and Equipment. The breakdown of the figures for the last five years is shown on Exhibit V and graphically on Exhibit VI. It is immediately apparent from these exhibits that the fluctuations in the total program expenditures parallel those in the Construction program while the other items remain relatively constant. It is obvious that total program expenditures can be predicted by forecasting the Construction program accurately and adding simple trend forecasts of the remaining areas. Likewise, since the program expenditures represent a fairly constant 92% of all expenditures, the grand total of all expenditures can also be easily produced.

The conclusion then of this analysis is that a cash forecasting system for the Department could be developed by concentrating on only the one significant area, the Construction Program. All other areas can be simple extrapolations from historical data except for Federal Aid Revenue which is also developed as a product of the Construction Program projections.

EXHIBIT V

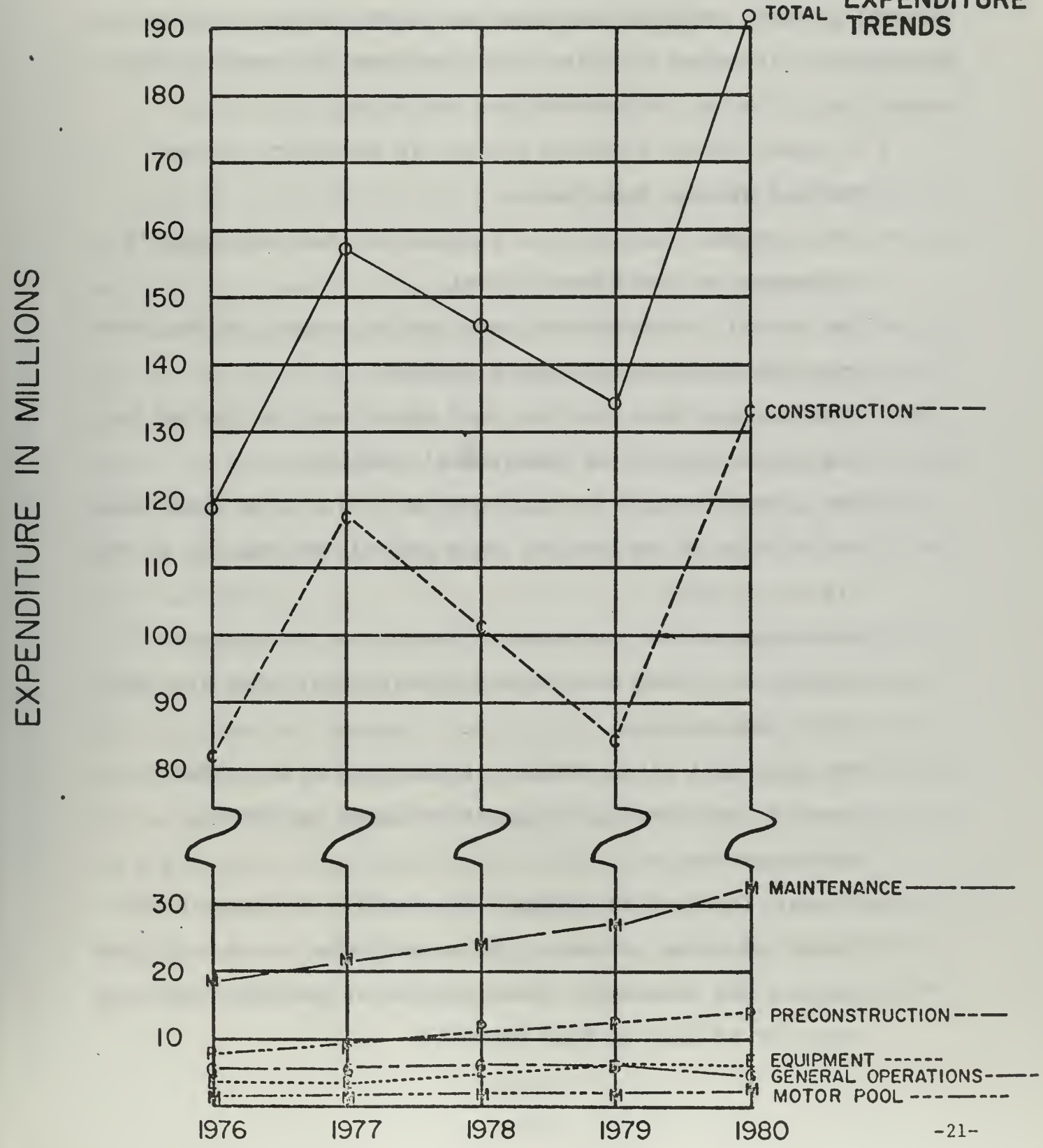
PROGRAM EXPENDITURES

Fiscal Year	1976	1977	1978	1979	1980
General Operations	5,751,793	5,730,609	5,929,439	6,538,276	6,880,299
Construction	81,966,248	117,929,887	100,393,684	84,018,104	132,979,833
Maintenance	18,980,224	20,181,569	23,167,810	25,390,407	30,189,637
Preconstruc.	7,379,750	8,504,599	10,157,070	11,541,295	12,284,071
Motor Pool	411,610	521,345	566,984	599,727	753,108
Equipment	5,058,414	4,653,085	5,606,832	6,328,478	7,053,387
Total	119,548,039	157,520,094	145,821,819	134,416,287	190,140,335
PERCENTAGE OF TOTAL HIGHWAY DEPARTMENT EXPENDITURES	92%	92%	91%	91%	92%

NOTE: The above table excludes Travel Promotion since this is no longer a part of the Department.

EXHIBIT VI

PROGRAM EXPENDITURE TRENDS



III Recommendations For Fiscal Planning and Cash Forecasting

As shown in the Summary of Findings, this study was able to identify several specific problems and needs which exist in the Department. In order to solve those problems and satisfy those needs, the following recommendations are made:

+ A formal Fiscal Planning Process is necessary in the Montana Highway Department.
+ This process should be a function of the Department's management at the highest level.
+ The use of a "management team" would probably be the best approach to implement such a process.
+ This process must include, but should not be limited to, the production of the Department's budget.
+ The process should be conducted on a virtually continuous basis so as to be able to react quickly to changes in the fiscal picture.
+ The Department's management should use this process to develop an integrated co-ordinated fiscal plan for the entire Department.
+ The plan will allow maximum utilization of available Federal funds and will support requests for future tax increases.
+ A cash forecasting system is essential to support the fiscal planning process. Management must be able to see clearly the projected fiscal status of the Department in order to be able to plan properly.

+ Such a cash forecasting system can be created despite its inherent problems. Other states have done and are doing so.
+ It is important that the limitations of a cash forecasting system be recognized and that it not be more sophisticated than necessary.

The specific type of Cash Forecasting System to be developed will depend on the flexibility, response time and level of accuracy which is necessary to uphold the Fiscal Planning process.

It is possible to project cash flow through rough but fairly reliable manual methods using gross dollars planned for construction in the next year and historical expenditure trends. This method is adequate if the Department is willing to carry sufficient cash balance as a contingency against fluctuations. However, one of the objectives of a cash forecasting system is "to minimize cash reserves".

The most effective way of creating such a system would be through the development of an automated Cash Forecasting Management Information System. This system must include in its data base; available funds (current and future); construction project schedules whether under contract, in preliminary engineering, or in a planning stage; and expenditures on current contracts.

In addition, construction projects must be classified by type and size. Examples of "type" could be bridge replacement, grading, surfacing, lighting, etc. Examples of size could be

lane miles, number of bridges, square feet of bridge surface, number of lanes, etc.

Other considerations are; the geography of the project's location; the estimated duration of the construction project; and the time of year that letting is scheduled.

Using the construction project classification types and sizes, schedules, locations, durations and seasonal considerations, cash payout curves can be developed from historical data (see Exhibits VII, VIII, and IX).

Of these curves shown, two are formula curves (Exhibits VII and IX) and one is a step curve (Exhibit VIII). It has been found that both methods work, but that the step curve is easier to maintain and modify since it can be equated to fixed percentage figures. It is also possible to develop several curves for projects and a separate "seasonal" curve which can be overlaid.

The curves, once developed, are placed in the system's data base. Each project then entered into the system is associated with a specific curve. This can be altered if the scope of the project changes or for any other reason. Likewise, the curves can be modified and updated if new historical records from recent project completions expose deficiencies or required changes.

The forecasting process can then be used to produce reports or graphs which detail the Construction Program's fiscal outlook for the future; by fund and by active projects alone or active and proposed projects combined (see Exhibits X through XX).

Projection Curve For Small And Large Size Construction Projects

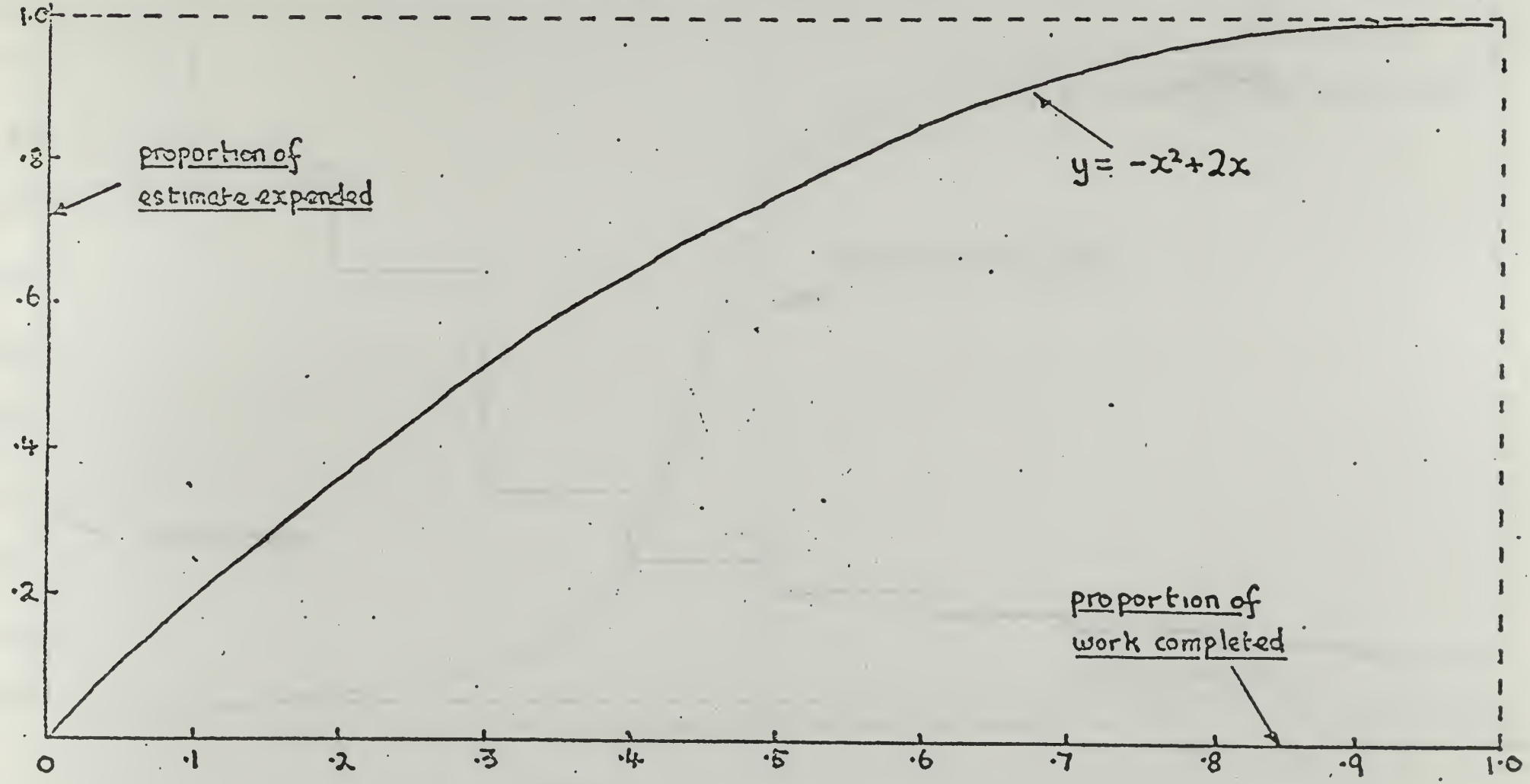


EXHIBIT VII

STEP CURVE FOR LARGE GRADING PROJECTS

(SPRING LETTING)

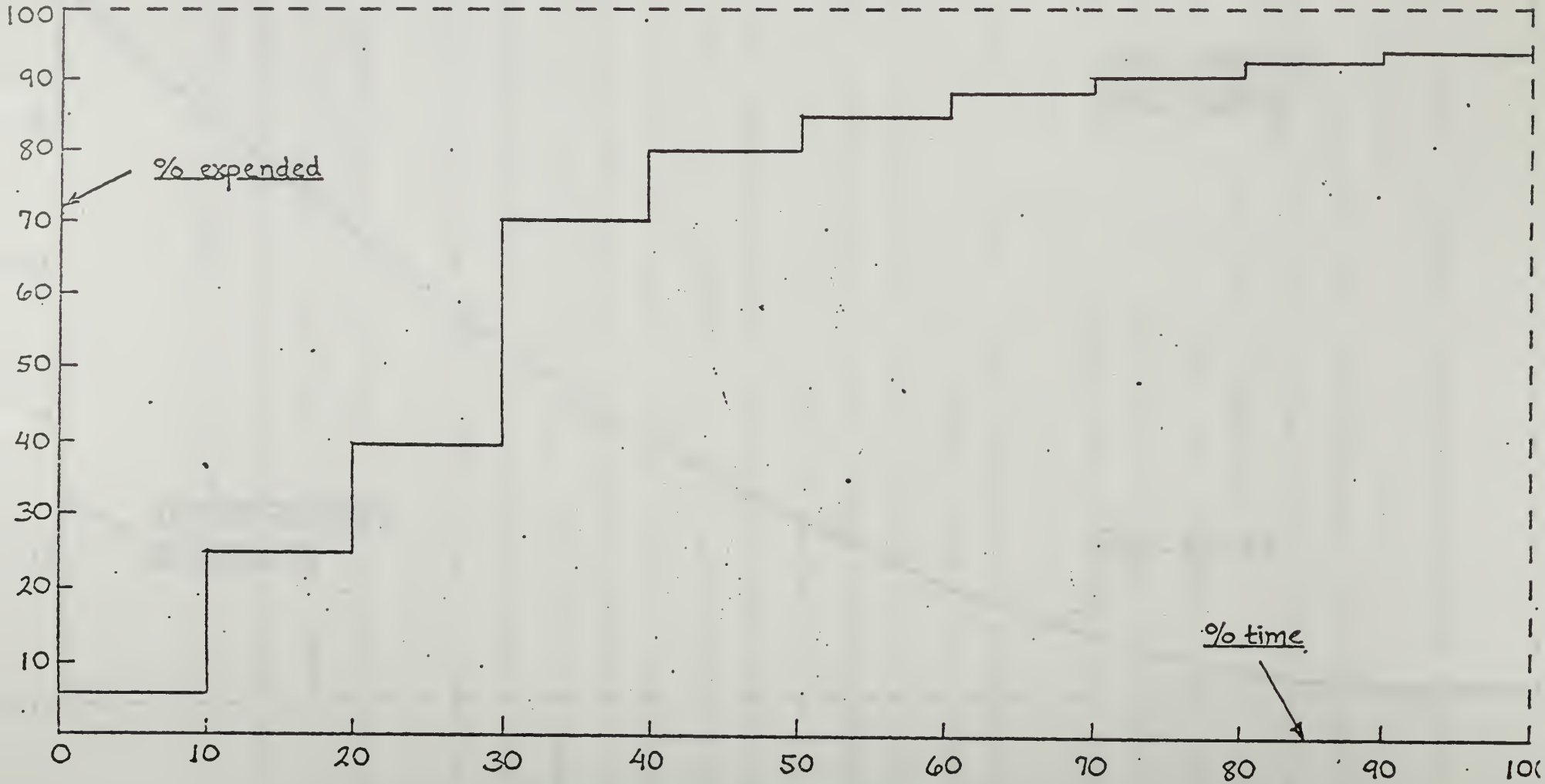


EXHIBIT VIII

PROJECTION CURVE FOR RIGHT OF WAY

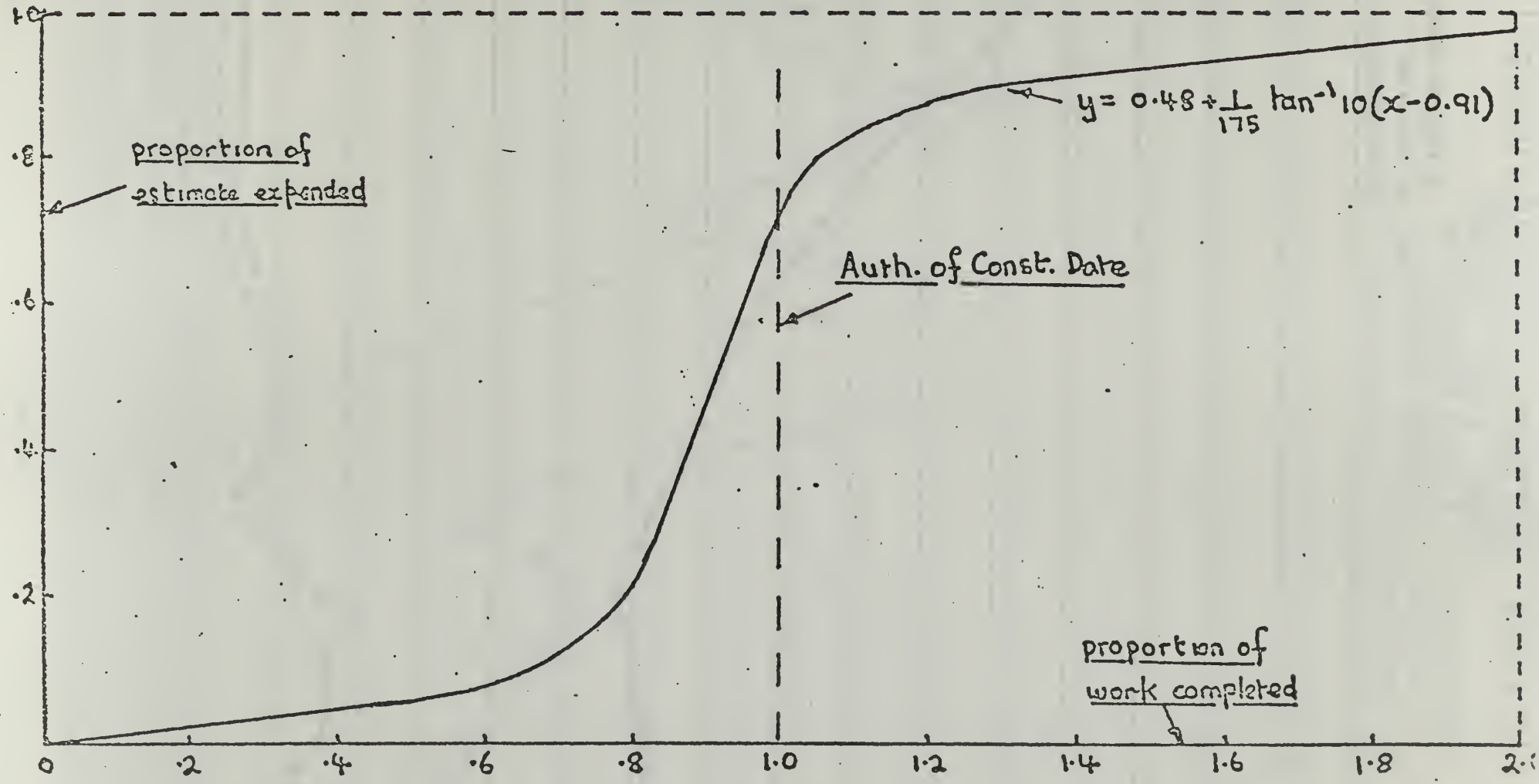


EXHIBIT IX

STATE HIGHWAY DEPARTMENT

CASH FLOW REPORT

1 1/2 ¢ CONSTRUCTION
ACTIVE PROJECTS

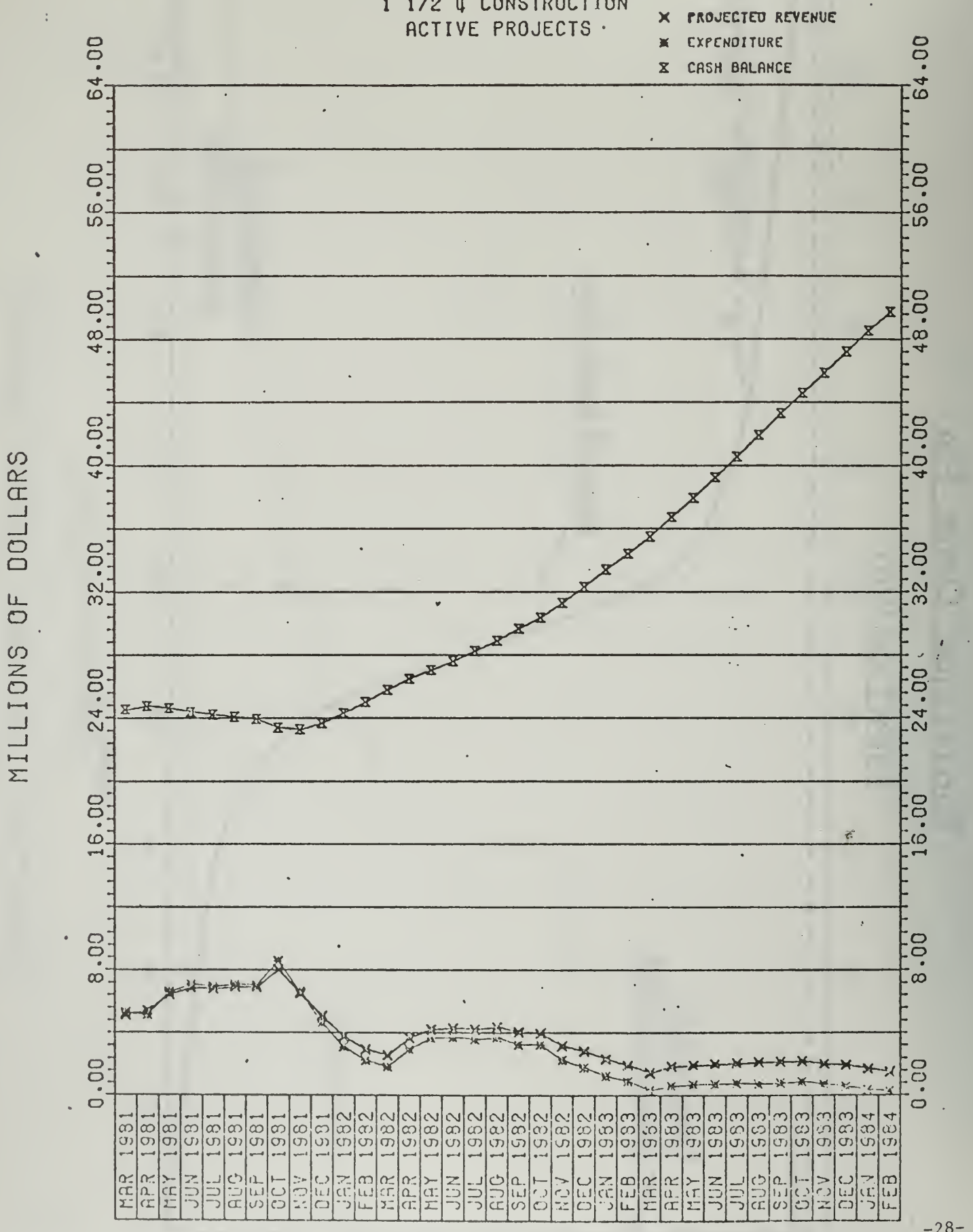


EXHIBIT X

03-09-81

STATE HIGHWAY DEPARTMENT

CASH FLOW REPORT

1 1/2 ¢ CONSTRUCTION
ACTIVE PROJECTS
AND PROJECTS PROPOSED
THRU 06/30/82

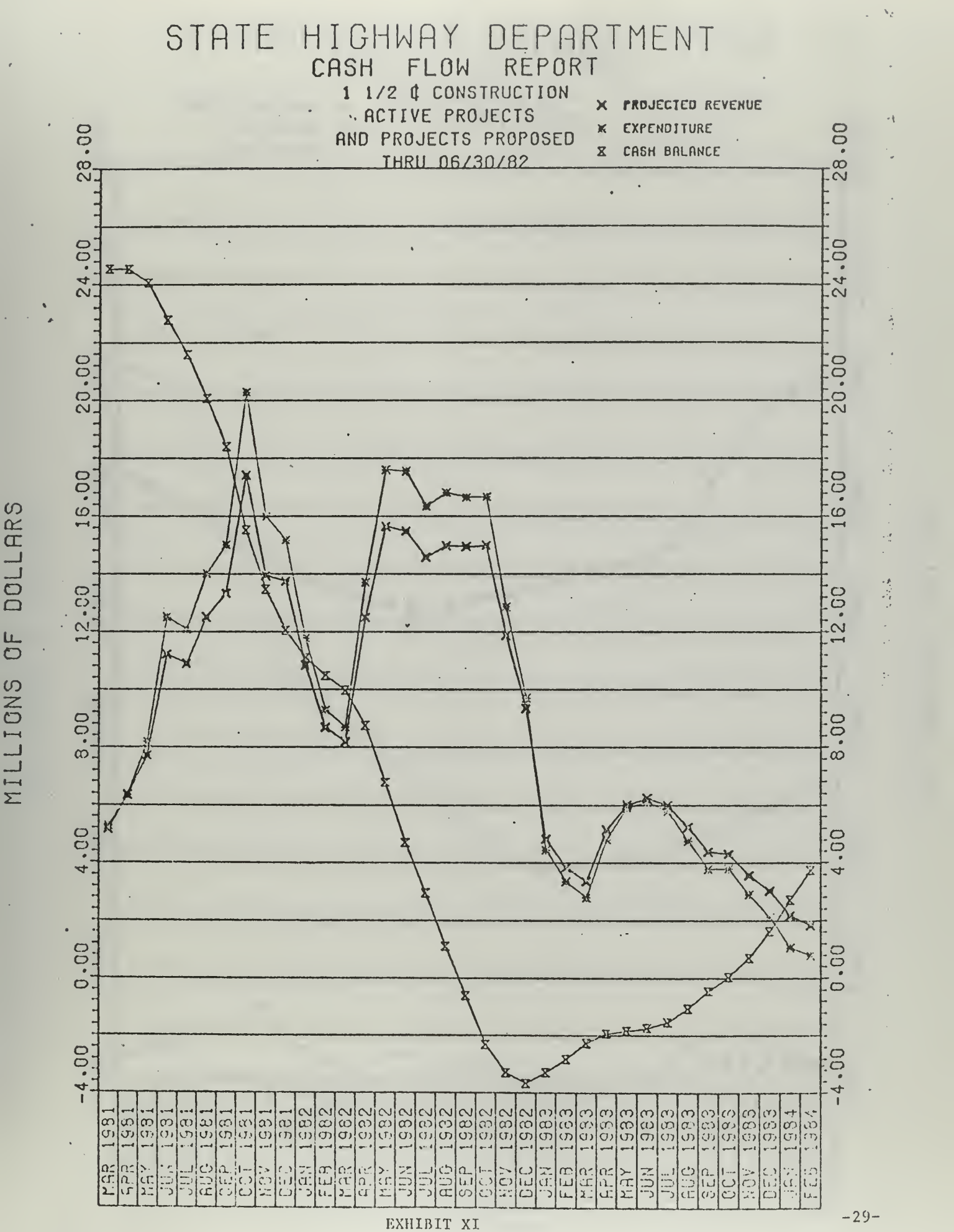


EXHIBIT XI

STATE HIGHWAY DEPARTMENT

CASH FLOW REPORT

20 % CONSTRUCTION
ACTIVE PROJECTS

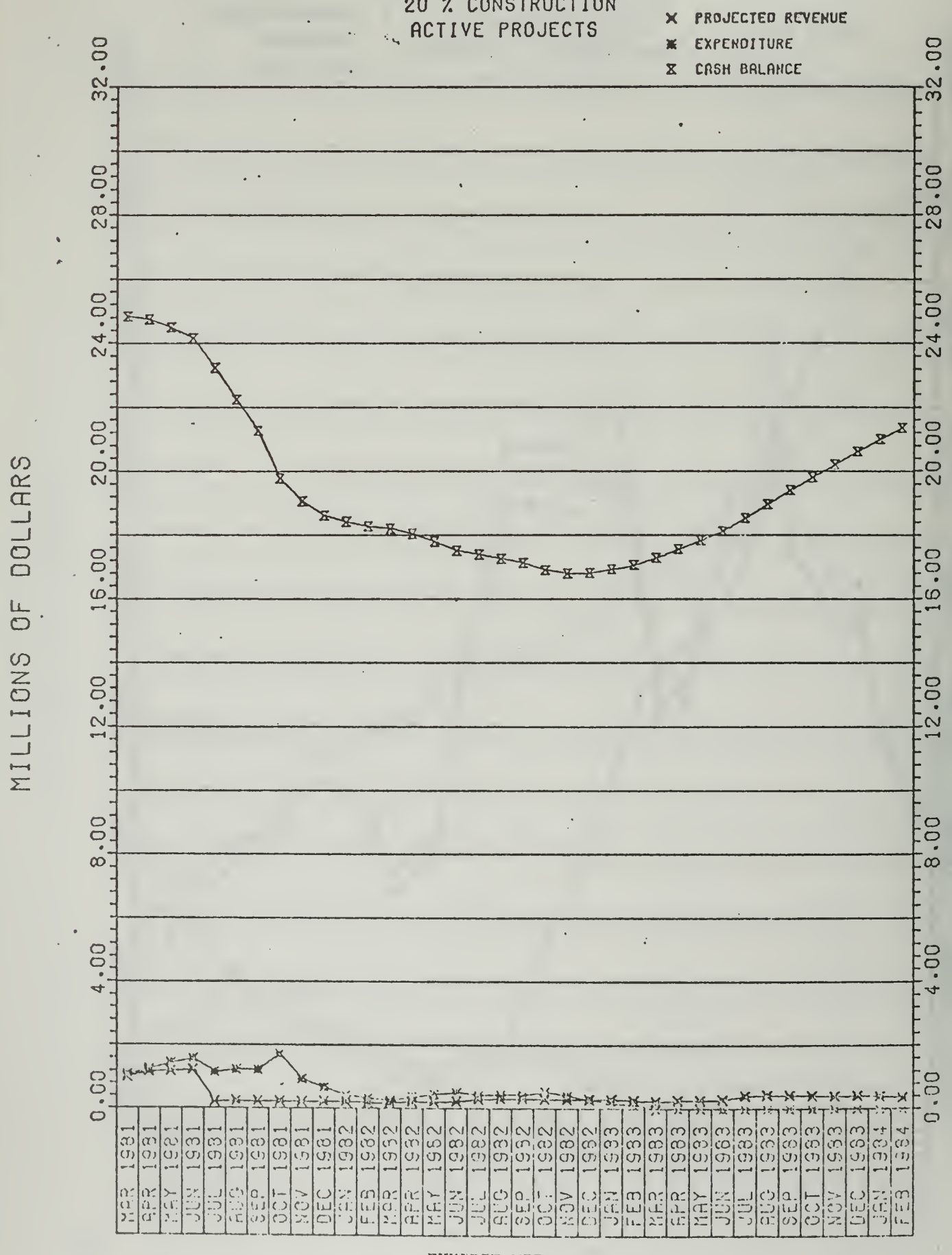


EXHIBIT XII

STATE HIGHWAY DEPARTMENT

CASH FLOW REPORT

20 % CONSTRUCTION
ACTIVE PROJECTS
AND PROJECTS PROPOSED
THRU 06/30/82

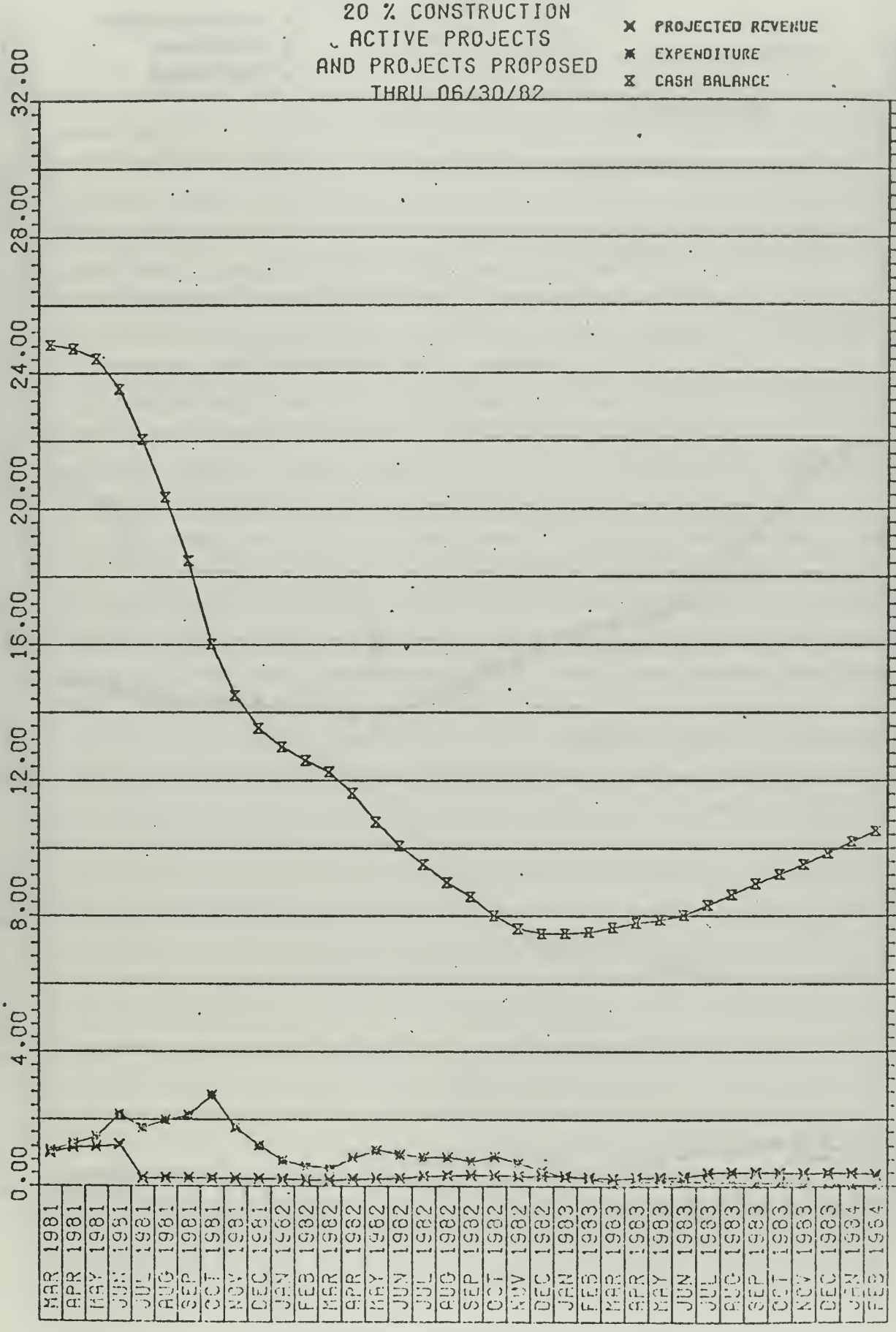


EXHIBIT XIII

STATE HIGHWAY DEPARTMENT

CASH FLOW REPORT

1972 CORRIDOR ACT
ACTIVE PROJECTS

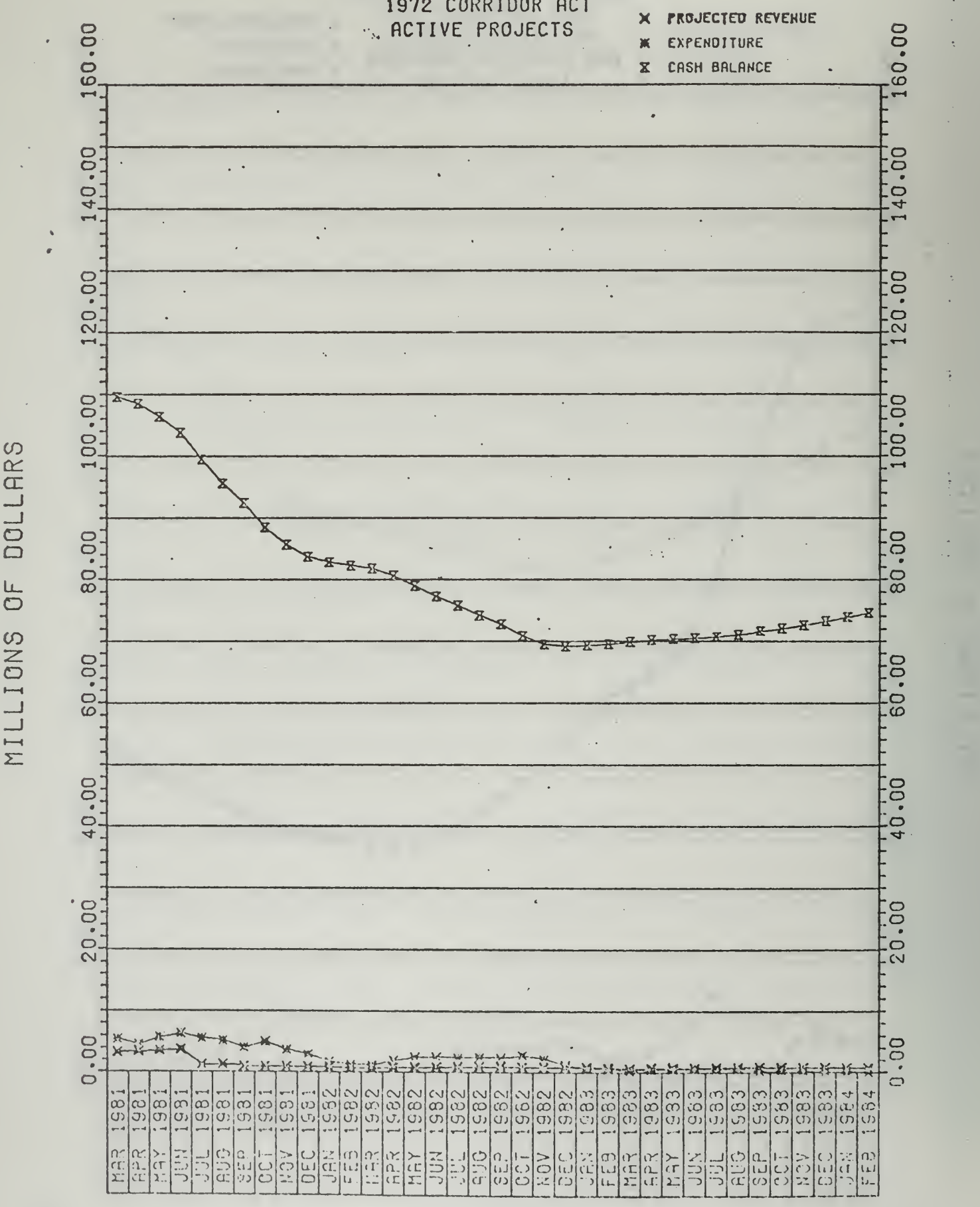


EXHIBIT XIV

STATE HIGHWAY DEPARTMENT

CASH FLOW REPORT

1972 CORRIDOR ACT
ACTIVE PROJECTS
AND PROJECTS PROPOSED
THRU 06/30/82

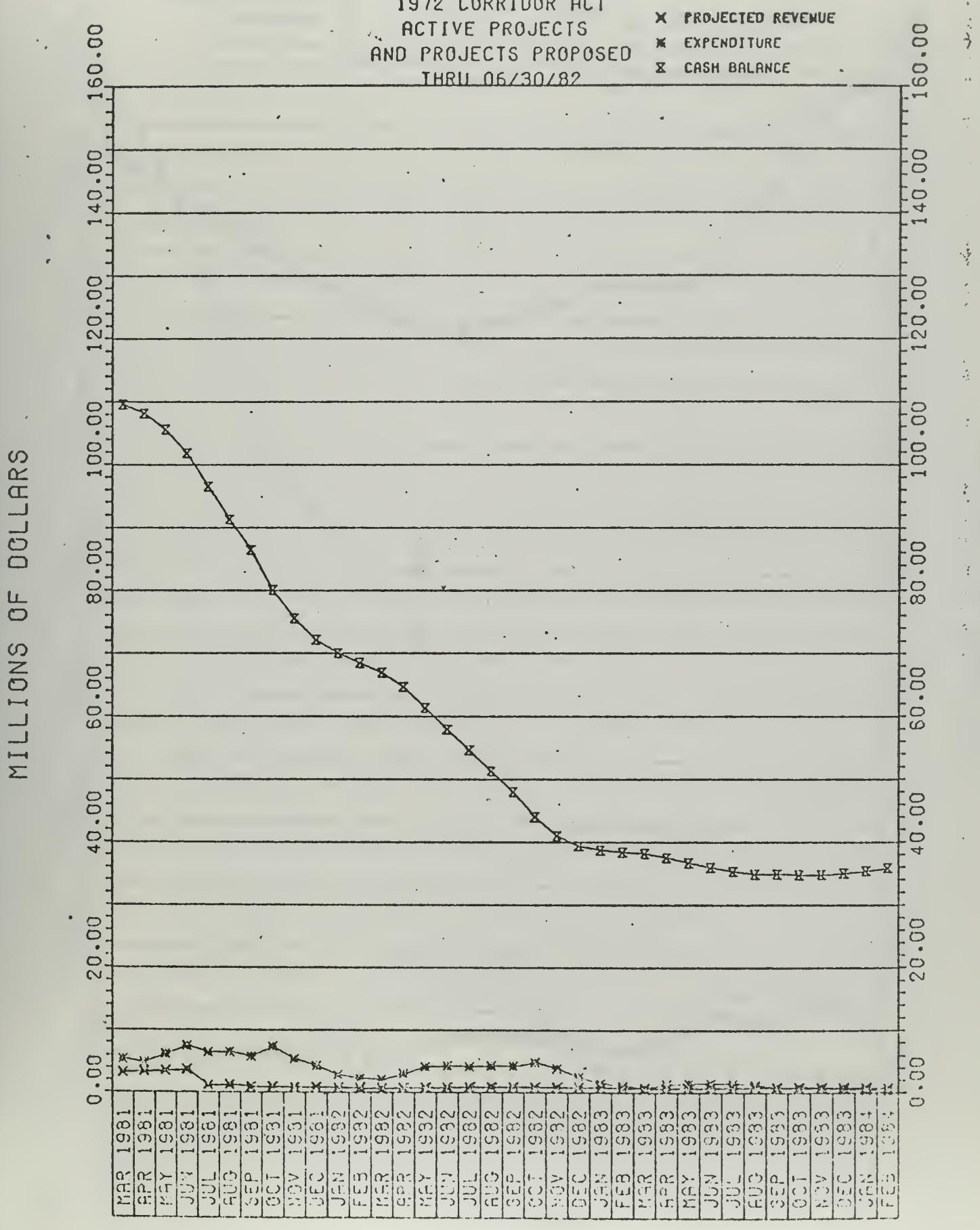


EXHIBIT XV

STATE HIGHWAY DEPARTMENT

CASH FLOW REPORT

TOTAL CONSTRUCTION
ACTIVE PROJECTS

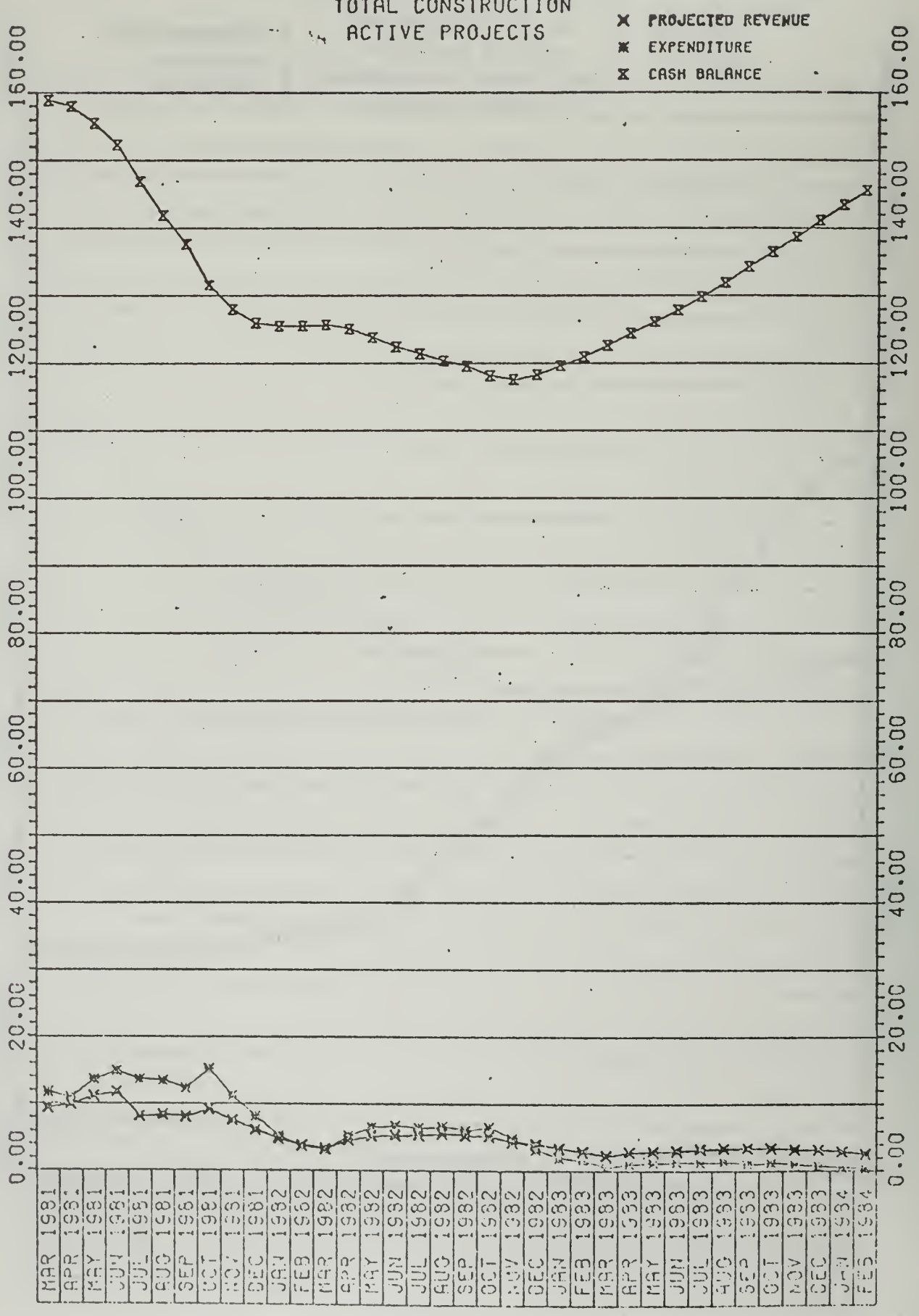


EXHIBIT XVI

STATE HIGHWAY DEPARTMENT

CASH FLOW REPORT

TOTAL CONSTRUCTION
ACTIVE PROJECTS
AND PROJECTS PROPOSED
THRU 06/30/82

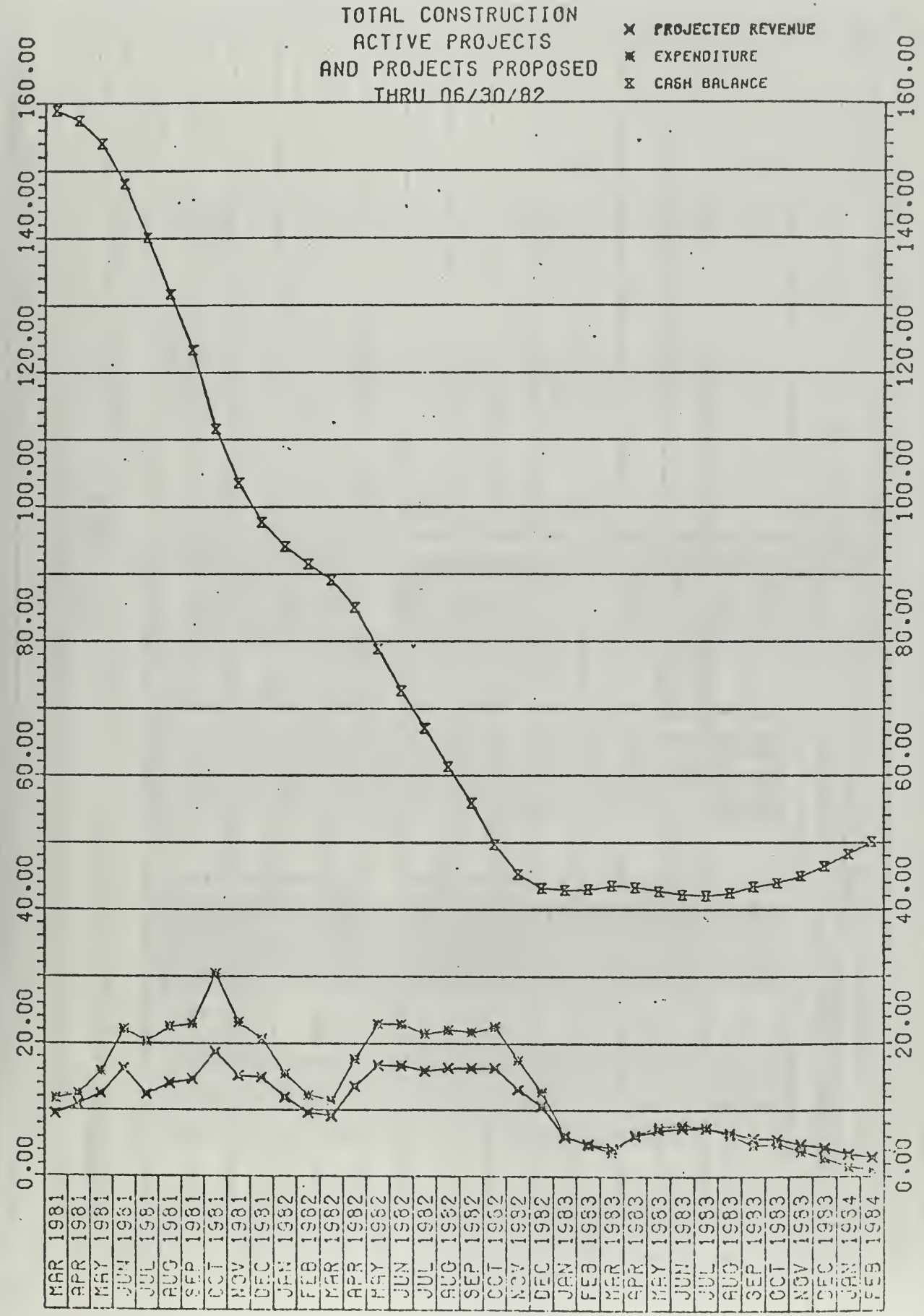


EXHIBIT XVII

EXHIBIT XVIII

CASH BALANCE FORECAST FOR FISCAL YEARS 1981 THRU 1983
NOVEMBER 30,1980

MON-YR	REVENUES		EXPENDITURES		CASH BALANCE	
BRT FWD					88,118,084	
JUL-80	47,988,083	A	60,145,666	A	75,960,501	A
AUG-80	45,142,575	A	78,804,566	A	62,498,510	A
SEP-80	77,517,529	A	106,738,654	A	33,277,385	A
OCT-80	74,004,980	A	76,865,594	A	30,416,771	A
NOV-80	46,051,414	A	59,617,187	A	16,850,998	A
DEC-80	95,338,179	P	81,489,570	P	30,699,607	P
JAN-81	79,846,918	P	62,345,899	P	48,200,626	P
FEB-81	104,563,252	P	59,818,051	P	93,945,827	P
MAR-81	63,641,366	P	64,732,015	P	92,855,178	P
APR-81	56,831,277	P	66,239,785	P	83,446,670	P
MAY-81	53,591,987	P	65,722,058	P	71,226,599	P
JUN-81	61,464,542	P	69,202,362	P	63,488,779	P
TOTAL	825,892,102		850,521,407			
JUL-81	58,110,408	P	55,913,722	P	65,705,465	P
AUG-81	51,636,491	P	55,344,831	P	61,997,125	P
SEP-81	55,422,194	P	92,173,433	P	25,245,886	P
OCT-81	51,792,704	P	58,205,467	P	18,833,123	P
NOV-81	47,956,176	P	49,464,124	P	17,325,175	P
DEC-81	45,028,814	P	42,590,129	P	19,763,860	P
JAN-82	53,158,645	P	42,130,200	P	30,792,305	P
FEB-82	56,108,584	P	40,108,660	P	46,792,229	P
MAR-82	46,602,943	P	44,807,326	P	48,587,846	P
APR-82	47,048,449	P	44,375,451	P	51,260,844	P
MAY-82	44,759,699	P	45,401,500	P	50,619,043	P
JUN-82	48,594,316	P	46,499,672	P	52,713,687	P
TOTAL	606,239,423		617,014,515			
JUL-82	45,225,325	P	39,434,943	P	58,504,069	P
AUG-82	39,185,610	P	40,055,422	P	57,634,257	P
SEP-82	43,628,491	P	76,899,611	P	24,363,137	P
OCT-82	40,654,604	P	44,908,544	P	20,109,197	P
NOV-82	36,699,256	P	36,146,512	P	20,651,941	P
DEC-82	34,863,200	P	30,557,624	P	24,957,517	P
JAN-83	43,823,471	P	31,588,684	P	37,192,304	P
FEB-83	47,313,739	P	30,241,345	P	54,264,698	P
MAR-83	38,365,087	P	35,491,766	P	57,138,019	P
APR-83	39,412,335	P	35,806,819	P	60,743,535	P
MAY-83	37,471,924	P	37,196,166	P	61,019,293	P
JUN-83	42,096,466	P	39,355,693	P	63,760,066	P
TOTAL	488,729,508		477,683,129			

NOVEMBER RUN 12/17/80

ACC94765

MONTHLY ESTIMATE VS ACTUAL
REVENUES AND EXPENDITURES
NOVEMBER 30,1980

CATEGORY	DESCRIPTION	ESTIMATE	ACTUAL	OVER/UNDER	PERCENT
REVENUES					
100	$$ ADJ				
110	TOTAL CURRENT FUND REVENUES	25,032,680	24,100,514	932,166-	3.72-
112	BOND FUND REVENUES M-2	4,808,580	197,166	4,611,414-	95.90-
131	FEDERAL AID REIMB M-1	2,884,091	1,780,653	1,103,438-	38.26-
132	FEDERAL AID REVENUES M-2	28,705,223	15,423,568	13,281,655-	46.27-
140	COLL ON A/R - PARTIC AND OTHER	1,666,250	1,819,448	153,198	9.19
150	TRANSFERS FORM GEN FUND				
160	COLLECTIONS ADJUSTMENT				
210	DEBT SERVICE FUND REVENUE	2,672,000	2,730,065	58,065	2.17
TOTAL REVENUES		65,768,824	46,051,414	19,717,410-	29.98-
EXPENDITURES					
400	$$ ADJ	3,467,719	3,467,188	531-	2-
405	GENERAL ADMINISTRATION	1,209,516	1,152,940	56,576-	4.68-
406	DOH GEN AND OPER ADMIN	1,841,705	1,870,329	28,624	1.55
410	STATE MAINTENANCE	13,475,740	13,501,653	25,913	19
415	FERRY OPERATIONS	478,349	570,714	92,365	19.31
420	POWELL BILL				
425	OSHA COMPLIANCE	13,500	55,207	41,707	308.94
430	DIV OF MOTOR VEHICLES	2,362,169	2,217,586	144,583-	6.12-
435	GOVERNOR'S HIGHWAY SAFETY	30,769	817-	31,586-	102.66-
440	EMPLOYER'S CONTRIBUTIONS	3,130,732	373,517	2,757,215-	88.07-
445	DEPT OF CRIME CONTROL & OTHER	3,572,707	2,800,000	772,707-	21.63-
455	RESERVES				
460	CAPITAL IMPROVEMENTS	337,926	24,503	313,423-	92.75-
465	AERONAUTICS ST AID TO AIRPORTS	316,450	184,078	132,372-	41.83-
470	PUBLIC TRANS-STATE AID	102,778	147,784	45,006	43.79
475	RAILROADS-STATE AID	8,330	2,445	5,885-	70.65-
480	MISCELLANEOUS GRANTS	41,650	1,567,084	1,525,434	3662.51
485	CETA		968	968	
490	STATE CONSTRUCTION M-1	2,384,383	3,323,825	939,442	39.40
493	SMALL URBAN BOND		388,558	388,558	
495	FED AID CONSTRUCTION M-1	2,718,844	2,370,399	348,445-	12.82-
496	PROPOSED SAFETY PROJ 25%				
498	UNCLASSIFIED METHOD 1		590,979	590,979	
499	UNCLASSIFIES METHOD 2	1,126,932	804,234	322,698-	28.64-
510	TRANS TO DEBT SERVICE FUND	2,672,000	2,730,065-	5,402,065-	202.17-
610	PRELIMINARY ENGINEERING M-2	1,228,131	1,281,331	53,200	4.33
620	RIGHT OF WAY M-2	8,691,096	3,256,760	5,434,336-	62.53-
630	CONTSTRUCTION M-2	22,661,992	22,395,987	266,005-	1.17-
TOTAL EXPENDITURES		71,873,418	59,617,187	12,256,231-	17.05-
CASH BALANCE PRIOR MONTH			30,416,771		
CURRENT REVENUES			46,051,414		
TOTAL AVAILABLE CASH			76,468,185		
LESS CURRENT EXPENDITURES			59,617,187		
CURRENT CASH BALANCE			16,850,998		

EXHIBIT XIX

ACC94736

02/05/81
PAGE 775

PROJECT PAYOUT BY FISCAL YEAR
DECEMBER 31,1980

NCHIP R506A PHASE C STATUS A PRIORITY DIV 13 COUNTY 86 MADISON ROUTE US025 LENGTH 0.559
SYSTEM 11 81 FA SYSTEM 010
PERCENT 025 075 PERCENT 100 DESCRIPTION FROM EXISTING US 25-70 NEAR MARSHALL EASTERLY
8.1906704

*** PLANNED **** **** PROGRAMMED ****
START DATE 11/80 PRO START DATE 11/80 DATE REVISED PLANNED EST 1,806,403 COST TO DATE 1,906
COMP DATE 07/82 PRO COMP DATE 07/82 DATE REVISED PROGRAM EST 1,806,403 DATE REVISED 01/81

CONST TYPE 030 FORCE ACCT/CONTRACT 2 FINANCE CODE 1 CURVE TYPE C030 COST UPDATE DATE 12/80

FY-81		FY-82			FY-83		
JUL	A	JUL	111,742	P	JUL	44,672	P
AUG	A	AUG	106,092	P	AUG		P
SEP	A	SEP	100,651	P	SEP		P
OCT	A	OCT	95,002	P	OCT		P
NOV	94 A	NOV	89,351	P	NOV		P
DEC	1,812 A	DEC	83,701	P	DEC		P
JAN	145,431 P	JAN	78,052	P	JAN		P
FEB	139,782 P	FEB	72,611	P	FEB		P
MAR	134,131 P	MAR	66,961	P	MAR		P
APR	128,482 P	APR	61,312	P	APR		P
MAY	123,041 P	MAY	55,871	P	MAY		P
JUN	117,391 P	JUN	50,221	P	JUN		P
TOT	790,164	TOT	971,567		TOT	44,672	

TOTAL ACTUAL TO DATE	1,906
REMAINING ESTIMATE	1,804,497
TOTAL	1,806,403

EXHIBIT XX

In addition to the capabilities already described, the need exists to simulate the effects of changes in the Construction Program. These changes occur as new projects are introduced while others are dropped in priority or are eliminated altogether. The availability of funding for projects is also dynamic and dependent upon state budgets, federal apportionments and the matching strategy for federally participating projects.

With an automated system, a cash forecast can be run against these proposed changes and the resulting effect on cash flow analyzed. At this point, a decision can be made by management based upon this and other information as to what real changes to make.

With these capabilities, the Department can effectively meet its responsibilities to maintain a positive cash balance and at the same time minimize the amount of reserves held for contingency. This will allow the Department to maximize the utilization of construction funds.

IV. Analysis of Technical Alternatives

There are three basic ways in which a Cash Forecasting Management Information system can be developed;

+ Manual system
+ Automated stand-alone system
+ Integrated sub-system of an overall Project Management system.

1. Alternative I - Manual System

As has been noted, it is perfectly feasible to produce cash forecasts manually. In fact, the chief of the Construction Bureau has been doing exactly that for many years for those projects let to construction. His technique is to evaluate each job individually based on its size, type, and letting date. He then relies on his experience to estimate the monthly payouts over the life of the job. For smaller jobs he estimates the total monthly payout while for larger jobs he will break his estimates down by major items such as grading, culverts, etc., over the anticipated construction schedule. He feels that his accuracy is generally good except when unanticipated changes in the weather alter the construction schedules.

Advantages

+ No automated system development costs
+ No computer operating costs
+ Sophistication level is kept to a minimum
+ System development would be very rapid.

Disadvantages

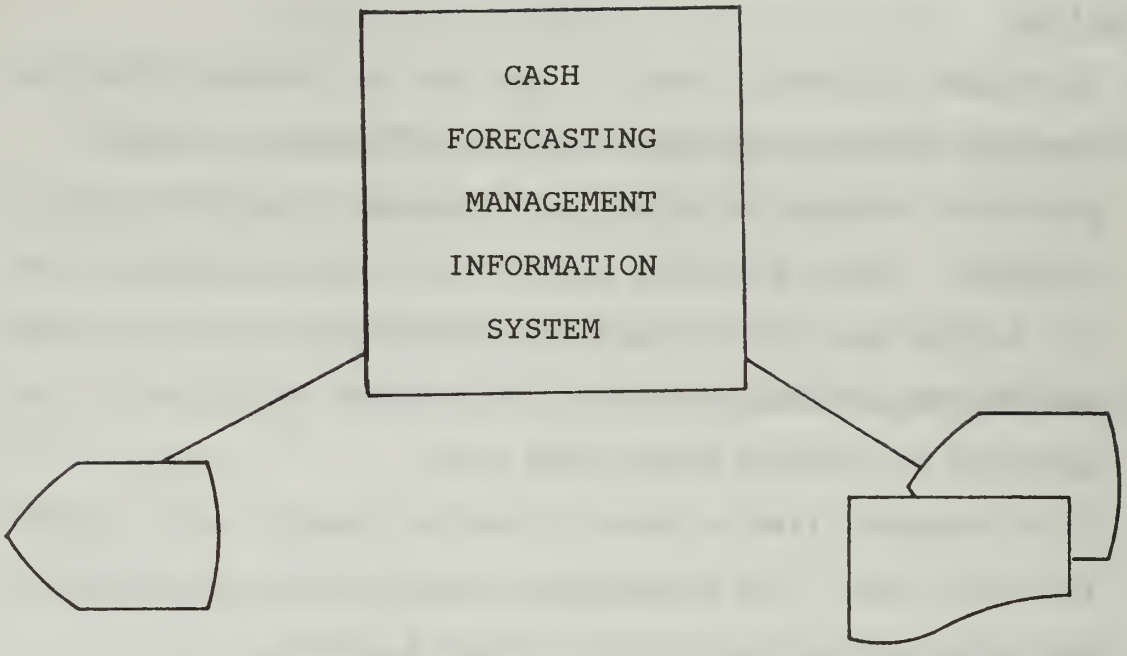
+ Increased personnel costs - the use of a Bureau Chief to prepare forecasts is questionable. Therefore, other personnel should be hired and trained to perform this function. More than one person would be necessary since all active and proposed projects would need to be forecast and the Department undertakes an average of 80 to 100 new projects of various sizes each year.
+ Slow response time - even if several people were trained for this task, the preparation of forecasts and reports can never be as fast as an automated system.
+ Limited Simulation Capability - due to personnel and response time constrictions, the potential of producing timely, detailed and accurate cash flow forecasts is severely reduced.
+ Limited Reporting Cabability - this method must, of necessity, be limited to a few standardized reports since the response time needed to produce specialized reports would require a long lead time.

2. Alternative II - Stand Alone System

This alternative would require the construction of a fully automated Cash Forecasting System independent of all other Departmental Management Information systems. An overview diagram is shown on Exhibit XXI.

Advantages

+ Meets all desired objectives for a Cash Forecasting System



INPUTS (Online Entry)

- Estimated Non-Federal Revenues
  - Gasoline
  - Diesel
  - GVW and Related
- Estimated Non-Program Expenditures
  - City-County Construction
  - Other Agencies
  - Miscellaneous
- Estimated Program Expenditures
  - General Operations
  - Maintenance
  - Motor Pool
  - Equipment
  - Pre-construction
  - Construction

OUTPUTS (Online Inquiry Screens, Printed Reports, and/or Graphs)

- Cash Balance Forecast
  - Total
  - By Fund
- Status of Revenues and Expenditures
- Fund Transfers
- Projected Expenditures by Project
  - Pre-Construction
  - ROW and Utility
  - Construction
  - Funding Split
- Project Status by Project
  - Pre-construction
  - ROW and Utility
  - Construction
  - Funding Split
- Exception Reports
  - Projects Exceeding Funding
  - Lapsing of Funds

EXHIBIT XXI

+ Rapid response time with online access
+ Good simulation capabilities
+ Flexible financial reporting capabilities

Disadvantages

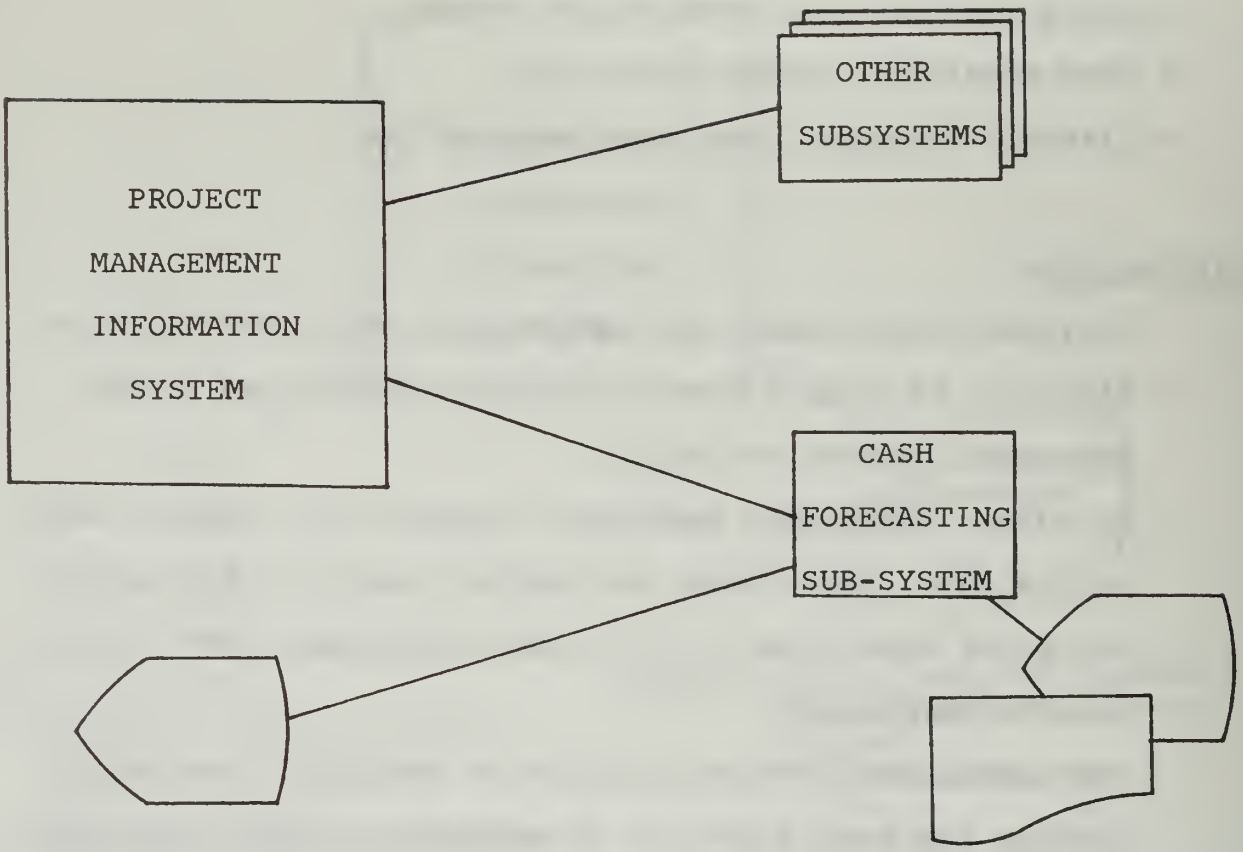
+ Increased development and operational costs over Alternative III if both a Cash Forecasting system and Project Management system are built.
+ As other independent management systems are created, much of the data, both input and stored, would be duplicated while the separation of other data might make some valuable reports unavailable.
+ The development and maintenance of multiple independent systems has been proven to be wasteful of Data Processing resources, both man and machine.

3. Alternative III - Sub-System of a Total Project Management Information System

This alternative would develop the Cash Forecasting system as an element of a total Project Management Information System. An overview diagram is shown on Exhibit XXII.

Advantages

+ Meets all desired objectives for a Cash Forecasting System.
+ Rapid response time with online access.
+ Good simulation capabilities.
+ Fully integrated Projects Data Base allowing specialized



INPUTS (Online Entry)

- Estimated Non-Federal Revenues
  - Gasoline
  - Diesel
  - GVW and Related
- Estimated Non-Program Expenditures
  - City-County Construction
  - Other Agencies
  - Miscellaneous
- Estimated Program Expenditures (excluding Pre-construction and Construction)
  - General Operations
  - Maintenance
  - Motor Pool
  - Equipment

OUTPUTS (Online Inquiry Screens, Printed Reports, and/or Graphs)

- Cash Balance Forecast
  - Total
  - By Fund
- Status of Revenues and Expenditures
- Fund Transfers
- Projected Expenditures by Project
  - Pre-Construction
  - ROW and Utility
  - Construction
  - Funding Split
- Project Status by Project
  - Pre-construction
  - ROW and Utility
  - Construction
  - Funding Split
- Exception Reports
  - Projects Exceeding Funding
  - Lapsing of Funds

EXHIBIT XXII

reports to be created as needed. These reports can include or be controlled by any of the numerous project variables on the Data Base, both financial and non-financial.

+ System development and operational costs are less than for Alternative II if both a Cash Forecasting system and a Project Management system are built

Disadvantages

+ Longer development time due to the creation of an entire Project Management Information System.

Recommendation

It is the consensus of the Steering Committee that the Department should implement a Manual Cash Forecasting System immediately as described in Alternative I. This would allow the Department to gain the benefits of, at least, a limited Cash Forecasting System in as short a time as possible.

However, the Committee recognizes the limitations of a manual system and feels that the Department should expeditiously pursue the development of an automated system. The choice of automated system alternatives will depend on the result of the decision made between the alternatives in the Pre-construction area. If the Department decides to build a complete Project Management System, Cash Forecasting should be included as a subsystem (Alternative III). However, if the Department concludes that such a total system is unnecessary, an independent Cash Forecasting System should be built (Alternative II).

V. Recommended Development Plan

The time and cost estimates for Alternative I in this section are based on the assumption that the manual system will attempt to meet as many of the development objectives as possible. The actual amounts necessary will depend on the extent of the system that is created. The estimate for Alternative III is derived from the Conceptual Design Report for the Preconstruction Project/ Program Management Information System.

If either Alternative II or III is chosen, the development effort should follow the standard phased approach used by the Department's Data Processing Bureau.

1. Development Tasks and Schedules

Alternative I

Within this alternative, there is really only one task - training new personnel in the methods of construction project payout forecasting. It is estimated that at least two new people should be hired and that four months would be required for training.

Alternative II

If this alternative is chosen, the development effort should include the normal steps of general design, detail design, and programming and implementation. The estimated time frames would be:

General Design	-	2 months
Detail Design	-	3 months
Programming and Implementation	-	8 months

Note that the above differs from the estimate for Phase III, Alternative III of the Preconstruction report. This is because some elements of the Cash Forecasting System would be developed during Phases I and II of that alternative.

Alternative III

Under this alternative the system would be developed as a part of the Preconstruction Project/Program Management Information System. The development schedule described in the Preconstruction report as Alternative I is presented. Note that the Cash Forecasting subsystem is the Phase III deliverable.

Develop as in chart 1.

Phase I

General Design for total system	-	6 months
Detail Design for Phase I subsystem	-	3 months
Programming and implementation for Phase I subsystem	-	8 months

Phase II

Detail Design for Phase II subsystem	-	3 months
Programming and implementation for Phase II subsystem	-	7 months

Phase III

Detail Design for Phase III subsystem	-	3 months
Programming and implementation for Phase III subsystem	-	9 months

PMIS DEVELOPMENT PLAN

ALTERNATIVE I

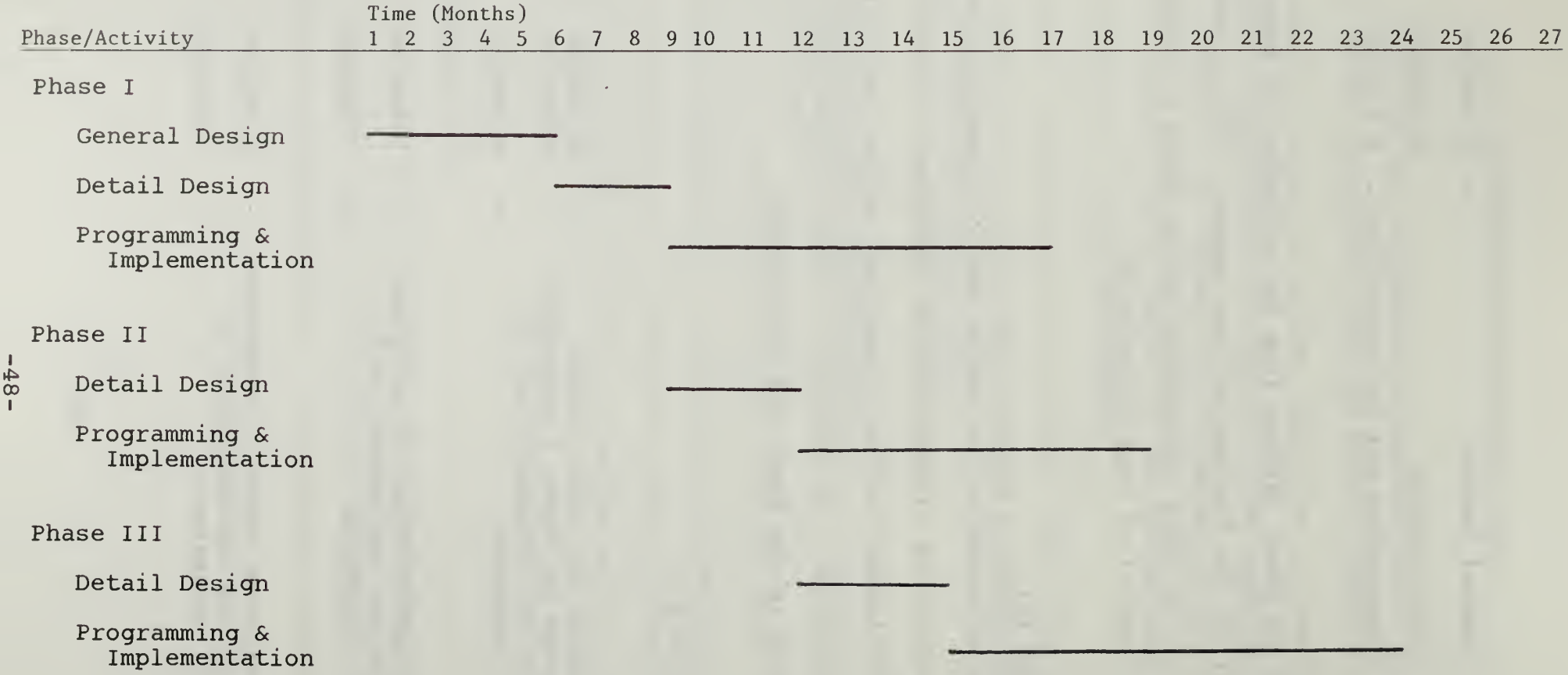

Time (Months)
Phase/Activity
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Phase I
General Design
Detail Design
Programming & Implementation
Phase II
Detail Design
Programming & Implementation
Phase III
Detail Design
Programming & Implementation

Chart 1

Phase I Deliverable -	General Design for total system and Detail Design and programming and implementation for project identification, project financing/funding, and fund management subsystems.
Phase II Deliverable -	Detail Design and programming and implementation for project scheduling and manpower management subsystems.
Phase III Deliverable -	Detail Design and programming and implementation for cash forecasting, simulation and evaluation and feedback subsystems.

2. Development Costs

Alternative I - Manual System

	MD's	Cost
Training	160	$ 24,000
Annual Operation	250	$ 37,500/yr.

The above figures assume that only state personnel would be involved in the training and operation of the system. Costs are calculated to be $150/man-day. As of May, 1981 the average monthly salary for the entire Department was $1,415 and the standard overhead rate was 40.6%. The assumption was made that somewhat higher level personnel would be involved and an average monthly salary of $2,000 was used.

Alternative II - Independent Automated System

Development Cost	MD's	Cost
MDH Staff		
Non-Data Processing	200	$ 30,000
Data Processing	300	$ 48,000
Consultant	200	$ 70,000
Computer Costs		$ 50,000
		$198,000

Operational Costs	MD's	Cost
Non-Data Processing Personnel	50	$ 6,500/yr.
DP Support		$ 10,000/yr.
Hardware/Software/terminals		$ 10,000/yr.
Computer Processing		$ 10,000/yr
		$ 36,500/yr
8 year operating costs		$292,000

TOTAL 8 YEAR SYSTEM COST $490,000

The above estimate is based on the assumption that a consultant will prepare the General Design, the Detail Design, and will manage the programming effort. Cost figures for state employees of $150/man-day for non-data processing personnel and $160/man-day for data processing personnel were used.

Alternative III

The following figures are derived from the estimate for Alternative I of the proposed Project Management Information System. The assumption is that the Cash Forecasting subsystem represents one-third of the total development and operating costs of the system.

Development Cost	MD's	Cost
MDH Staff		
Non-Data Processing	167	$ 25,000
Data Processing	267	$ 43,000
Consultant	233	$ 82,000
Computer Costs		$ 33,000
		$183,000

Operational Costs	MD's	Cost
Non-Data Processing Personnel	50	$ 6,500/yr.
DP Support		$ 7,000/yr.
Hardware/Software/Terminals		$ 8,000/yr.
Computer Processing		$ 8,000/yr.
		$ 29,500/yr.

8 year operating costs	$236,000
TOTAL 8 YEAR SYSTEM COST	$419,000

3. Savings and Benefits

A serious effort was undertaken to quantify the savings and benefits which would accrue as a result of the development of a Cash Forecasting System. Several key managers were interviewed for this purpose. However, with only one exception, the interviewers were unable to obtain solid estimates of time or cost savings. The exception is:

Reduction of Work in Project Control	Savings
+ Annual savings	
20 man-days per year	$ 2,000/yr.
+ One time savings	
120 man-days	$12,000

Although these savings cannot begin to equal the system cost, it is felt that much greater savings will develop as the Cash Forecasting System realizes its potential as a major planning tool.

In terms of non-quantifiable benefits, a Cash Forecasting Management Information System will;

+ Assist in the preparation of the Department's budget
+ Assist in the management of Federal Aid fund programs
+ Help minimize cash reserves
+ Serve as an intra-Departmental project status communications tool
+ Provide supporting data for funding level requirements.

R.J. HANSEN ASSOCIATES, INC.

MANAGEMENT AND INFORMATION SYSTEMS CONSULTANTS

PRE-CONSTRUCTION

MANAGEMENT INFORMATION NEEDS ANALYSIS

FOR THE

DEPARTMENT OF HIGHWAY
STATE OF MONTANA

July 1981

FINAL REPORT

SYSTEM CONCEPTUAL DESIGN

for a

PRE-CONSTRUCTION

PROJECT/PROGRAM MANAGEMENT INFORMATION SYSTEM (PMIS)

STATE OF MONTANA

DEPARTMENT OF HIGHWAYS

Prepared by

R. J. HANSEN ASSOCIATES, INC.

July 1981

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I. INTRODUCTION

Purpose of Report

This report is intended to determine and document the major problems and problem symptoms and to make recommendations for information systems development to help solve those problems that are related or caused by inadequate or untimely information.

The report is organized in the following manner:

- To provide background to the information needs.
- To present and explore information system alternatives.
- To recommend a system development plan.

Project Background

Historically the Montana State Highway Department has programmed more projects into the five-year construction program than the Department had manpower to develop or funds to contract them. Because of this, there has been increasing pressure on the Project Development staff (Pre-Construction and Right of Way) to get more work (designs complete and row clear) ready for letting. This has forced the staff to concentrate on short term development work and allow little or no time for planning or developing a long range development schedule. The current staff in these areas are committed nearly 100% to line functions (design, row acquisition, plan preparation, etc.). Consequently staff functions (planning, coordination, training, etc) has been lacking. Some of the results of this phenomena are:

- Missed target dates
- Poor staff communication
- Inadequate coordination among functions
- Lack of confidence in the plan by the staff, legislatures and the public

- Design short falls because of deadlines
- Crisis schedule management

It was because of this that the Montana Department of Highways initiated a study to determine the cause and extent of the problems and to arrive at a viable management system to correct them.

Summary of Recommendations

For any management system or management information system (MIS) to be effective it must be used and supported by the Department's Top Management. They must be ready to base their decisions on the information provided by the system. If this is not done no MIS will function properly or effectively. If department management makes decisions regarding project schedules and department objectives based on external pressures and demands and disregarding internally generated information then no MIS no matter how complete or sophisticated will be effective.

Specific Recommendations are:

- Department should endeavor to adopt and implement recommendations 1 thru 8 from the report "Conceptual Design and Plan for Decision-Making Aspects of a Project Formulation, Selection and Priorities Management System".
- Establish a realistic letting plan.
- Move design and design decisions closer to the work.
- Establish a better definition of project responsibility.
- Expand the monthly letting meeting.
- Reduce preliminary engineering costs through value engineering, decentralized decision responsibility, and better and more timely project priority and status information.

- Improve Department internal and external communications through organizational and policy procedures.

- Establish a better definition of project scope and guidelines for maintaining scope.

- Develop and implement an automated project management system.

    + Establish a steering committee to manage the development and enhancement of PC/70 scheduling and manpower system.

    + Develop a fund management and project funding system as proposed in Alternative V in Section IV of this report to support and complement the PC/70 system.

II. SUMMARY OF FINDINGS

Overview of Current Situation

The MDOH is currently experiencing various problems and challenges in preconstruction and project programming.

- Extreme pressures to meet letting and other critical schedule dates.
- Uncertainties of Federal Fund amounts.
- Increasing demand for highway improvements.
- Changing schedules.
- Increased construction and design costs.
- Communication shortfalls.

Findings

In any management study the emphasis is on determining what the problems are and identifying potential changes to the organization, procedures, information flow and content, etc. to correct the problems. This is where the effort has been concentrated in this study. This emphasis on problems and information needs does not mean that the Department is not doing things right and proper in many ways. It is evident that the work is getting done by the physical completion of roads and roadway improvements. These positive aspects of the Management System should be retained and concentration should be on improving the short comings.

Information System Problems

Several problems were discovered and documented during the study which impact the overall management system. All the problems, while identified individually are related to each other in some manner or another.

- Project priority is not established, not supported by top management and not communicated.
- There is a definite lack of credibility in the published letting dates.
- Communication flow is inadequate and untimely.
- Letting meetings are not complete.
    - + The current letting meeting does not cover a large enough time span. It should be expanded to include "best estimates" on projects in the entire five year plan. Additional attention should be paid to the other critical dates mentioned below.
    - + Also not enough adequate milestone dates that have been established are included in the meeting discussion and evaluation. Primary target date is the letting date. Other milestones need to be

discussed such as; ROW plans to row, survey complete, row complete, etc. These dates should dictate modifications in the letting schedule if so warranted.

- Inadequate information is produced and distributed both in initial project scope and subsequent scope changes.
- No long range operational plans are being developed.
- Preliminary engineering costs are high.
- Uncertainties in Federal apportionment amounts and balances.

Non Information System Problems

- Survey work is too dependant on seasonal work.
- Difficulty of making meaningful assignments to construction engineers because of increased use of photogrammetry for survey.
- Department training both formal and informal is inadequate.
- Working conditions for technical work are poor.
- Function and task coordination relating to plan in hand and other field reviews needs improvement.
- There is a very limited amount of flexibility in the Department's personnel recruitment procedure.

Recommendations

- Decentralize design functions and utilize construction engineers for 3 R type designs during winter months.
- Establish firm project priority arrays and reduce crisis schedule changes.
- Expand monthly letting meetings to a monthly scheduling meeting.
  - + Include a larger time frame of critical dates.
  - + Include more critical milestone dates in the discussion.

- Establish pre plan in hand meetings internally prior to field review.
- Allow line offices and functions more discretionery decisions in hiring procedures.
- Continue and expand the use of Value Engineering in Preconstruction activities and decisions.
- Develop and implement an automated Project/Program Information System to provide the information conceptualized in Section III of this report.

Information Sources and Needs

The staff is fairly well satisfied with the type of information they are receiving. Also, it appears that for the most part the various Preconstruction managers are using the same information. A considerable amount of dissatisfaction was expressed with the credibility and timeliness of the information. The major source of management information used for making major decisions is manually generated and distributed by word of mouth informal meetings.

SOURCES

+ Project Control Board

Monthly copies of the project status boards located in the Project Control unit are distributed widely to all areas in the preconstruction. The information is used throughout the Bureau. It lacks credibility in regards to target dates. Some areas are modifying the format of the report to make it more useful.

+ Letting List and Letting Meeting

List prepared from five year program and updated from results of monthly letting meeting. There is a lack of confidence in the projected letting dates in the list and discussed at the meeting. Also, the discussions and lists are too restrictive in detail. It should be expanded to cover all critical schedule dates and to cover a longer projection period.

+ Project Status Reports

Detail listing prepared by Project Control. This list again lacks credibility.

+ Split Memos

Memorandums prepared by Preconstruction Bureau whenever a project is divided for letting a portion at one time and delaying the remainder. It contains a description of the new scope of the divided projects and appears to have a wide and substantial distribution. There appears to be some question as to whether the revised scope definition is complete enough.

+ Plans/Designs

Designs and Plans of projects in development stage. Apparent satisfaction in the content of these was expressed. Some reservations regarding the proper distribution was expressed. Also, the coordination of plans developed by various sections was lacking.

+ Five Year Plan

Contains descriptions and target letting dates of all projects in the five year program. There is very little confidence in the letting dates and it is widely held that some of the projects will not get to letting for some time and probably not within the 5-year plan period.

+ Misc. Memos

Memorandums pertaining to project modifications, schedule changes/accomplishments, etc. Response varied as to the adequacy and effectiveness in this area. Feeling was somewhat similar to the problem expressed above relating to inadequate communication. In some instances and areas it was good, in others it was lacking or absent.

+ PC/MMS Project Control Manpower Management System

The only automated information system being used. The areas that used it extensively were quite satisfied. Other areas were quite vague as to what the system capabilities were and what type of support it may provide. It provides good support to the budgeting process. More training and direction in how to use it was indicated as necessary. The system is deficient in the support of the project funding area and financial planning (cash flow projections). Concern was also expressed as to the inability of the system to identify cri-

tical dates and activity time requirements. The major objective of a Project Scheduling/Manpower Management System is to keep it simple and easy to use. Activities and milestones should be kept to a minimum so that the ability to manage the project rather than managing the system is maintained.

+ Manpower Planning

Various methods of manpower planning information were identified by several persons interviewed. They were all manually generated and updated systems. The primary constraint was the difficulty to keep it accurate and current.

NEEDS

+ Automated Manpower Management

Information giving manpower required based on the project schedule and manpower available to the skill level (professional/technical) is desired. It should also provide feedback as to actual manpower used and support the budgeting process by projecting staff deficiencies and potential idle time.

+ Project Scheduling System

A simple, easy-to-use project scheduling system that provides the capability to monitor and manage critical project milestones and activities.

The two information needs identified above could be provided with continued development of the PC/70 system. It should be developed using a steering committee of users to manage the scope and extent of the development and support the implementation.

+ Financial/Funding Information

Information showing fund balances in relation to the current project schedule and in relation to time (both obligated and unobligated balances plus programmed and unprogrammed balances) should be available. This would support project funding, financial planning, cash flow projections and insure against lapsing funds.

+ Project Estimate Costs

  More complete and accurate costs of projects during the programming function. This cost should reflect the inflation factor in relation to when it is projected to be let.

+ Scope Definition

  More complete descriptive information as to what is involved in a project when it is defined and also when scope changes occur. Also the distribution of this information is critical.

+ Information Flow

  Information is needed about what information is available and who is responsible (where it originates) for that information and who should receive the information.

III. INFORMATION SYSTEM CONCEPTUAL REQUIREMENTS

The purpose of this section is to present the conceptual Project Management Information Requirements for the Montana Department of Highways to manage the preconstruction and construction program.

Some typical questions that should be asked and resolved when developing or evaluating an information system might include the following:

- Like many information systems, do the reports on the projects reflect accounting practices, or do they fulfill management needs?
- Do workable program management practices really exist or do managers mainly perform "after the fact"?
- Do current procedures give you enough depth to completely analyze and plan effectively? Are these manual processes cumbersome and time consuming?
- Is developing and updating a multiyear work program simply a required exercise or is it used effectively as a mangement planning and development resource?
- When developing a five year plan, does cash forecasting help set contract award dates?
- Can you evaluate the long term (or short term) effects on projects' funding and associated schedules when new projects are introduced or priorities shifted within the work program? Or, are you forced to manage the work program on a day-to-day basis?
- Can you react to a schedule change? Are funds ever lost due to an incomplete schedule?
- Does your work program contain substantially more projects in preconstruction phases than can be financed for construction because of uncertainties in fund availability and constraints? What is this over designing costing?
- What are the consequences of crash programs? Can you react to change?
- What data are being collected? What is being done with them? What data should be collected and processed?

How? What do you need to know? What do the managers need to know?

A Project/Program Management Information System for the Montana Highway Department should include information and processes of the following types:

- Project Identification
- Project Scheduling/Monitoring
- Manpower Management
- Project Funding/Financing
- Fund Management
- Cash Forecasting
- Simulation

These components of a PMIS are explained in further detail on the following pages.

Project Identification

This segment includes location, type of work, scope description, project priority, size in miles, lanes, square feet, etc., project ancestor relationship and related information necessary to identify the work to be done and where, on the highway system it is to be located.

Some types of information that would be available from the project identification segment would be:

1) Project lists by specific location (town, route, county financial districts)

2) Project lists by highway system, type of work, priority etc.

3) Project lists related to specific time periods

   - Projects initiated between July 1, 81 and June 30, 82, etc.
   - Projects with a proposed or actual letting date between two specific dates.

4) Project predecessor or successor relationship to trace project history through the entire development process (this information is pertinent to the situation when projects are split for subsequent letting at different times).

Project Scheduling/Monitoring

This segment should provide critical milestones dates, both target and actual, in the development life of the project. It should support both automated generation of a project schedule based on predefined project parameters or planning values and manual generated schedules established by entering projected target dates. In either scheduling process (manual or automated), it must provide the user the capability to modify the projected target dates based on current knowledge of the particular project. Scheduling parameters or project planning values used for automatic schedule generation should be developed in relation to the type of work, the time of year the work is to be performed and the type of geography at the location of the work. The initial attempt to create these planning values would probably be a manual effort and would be subject to a degree of subjective error. After a period of use, history could be obtained regarding the accuracy of the planning values and they could be modified accordingly.

Some types of information that would be available from the project scheduling/monitoring segment would be:

1) Complete project status including accomplished milestones and upcoming milestone dates. This information could be for selected projects or all projects.

2) Listing by activity of all projects that are in particular activity stages.

3) Information relative to near term critical dates in the project schedule.

4) Exception conditions regarding missed schedules or potential schedule delays.

Manpower Management

This segment is closely related to project scheduling/monitoring and where project scheduling establishes and predicts when particular activities are to be performed and whether activities and milestones have been accomplished, manpower management provides information regarding the level of effort required to perform the activities. It will also compare the level of effort required (by skill and function) to the resources available in the same skill and function. Manpower management information must be dynamic. As project schedule and scope changes occur, this should be reflected immediately on the manpower requirements.

Some of the types of information available from the Manpower Management segment would be:

1) Information by project, activity and function or skill relating to manpower needs.

2) Information relating to total manpower needs by various headings (total state, function, skill, etc.) and related to manpower available by the same heading, all time related (for specific planning period.).

3) Graphical information showing when, based on the current plan and schedule, manpower will be over committed, under committed, etc.

4) Information relative to the impact of schedule changes on the manpower requirements/availability curves.

5) Information relative to the actual man days used by activity, project, skill etc.

Project Funding/Financing

This segment should provide information relative to the projected dollars required to perform the construction and preconstruction programs. It should indicate where the funds are to be obtained. Fund sources will be identified and associated with a specific amount. Fund sources should include Federal funds (Primary, Secondary, Interstate, etc.), state match required (also identified by various fund sources if desired) and any local funds that might be involved. Fund amounts should be identified by an evolutionary step process; i.e., they are first programmed for a particular work program, then obligated with an agreement with the particular funding source and finally expended as the work is accomplished. They should also be identified in relation to the work phase or funding stage (Preliminary engineering (PE), Right of Way (RW) and Construction (CN)). Funds may be obligated in the PE fund stage but still be in the program stage for construction work. These amounts are identified at the project level and should be dynamically related to the various fund sources so that current balances are maintained for all fund sources available to the department.

Some of the information types available from the project funding/financing segment would be:

1) Current project financial status.
2) Projects financed by a particular fund source.
3) Project status by fund stage (PE, ROW, Construction).
4) Total work program (5 year plan) costs.

5) Work program overrun/underrun amounts.
6) Change order amounts.
7) Project expenditures versus project obligation amounts.
8) Exception reports indicating potential project overruns, program overruns.

Fund Management

This segment is closely related to the previous project funding/financing segment. It should provide information relative to all the fund sources available or to be available to the department to support the departments operations. Amounts should be identified by amount and fiscal year of availability. In addition future projections should be maintained for fund source amounts that are expected to be available in the particular planning period desired. It should reflect by an interface to the project funding/financing segment what the balances are after the various evolutionary steps in the program development cycle (balance after current obligations, balance after next years and the following years projected obligations, etc.). It should provide the capability to predict any lapsing fund potential based on current and projected obligations. In addition, it should provide the capability to maintain and report any fund transfers from one source to another should this become an objective of the department.

Some of the information types available from the Fund Management segment would be:

1) Fund balances by fund source (Interstate, primary, etc.) and fiscal year.
   a) After current obligations.
   b) After projected obligations (obligations expected for next year and the following years).

2) Potential lapsing fund conditions.

3) Total obligation amounts all fund categories or selected fund categories by time period.

4) Future expected apportionment amounts.

5) Transfer fund amounts and source of transfer (secondary to primary, etc.)

Cash Forecasting

This segment would provide information relative to the expected cash receipts, expenditures and balances of the department. It would depend on the project scheduling/monitoring segment for time of expenditure and on the project funding/financing segment for the level of expenditure. Payout profiles or models would be necessary to predict the amount of cash dollars to be paid at any time. The pay out would be developed at the project level and be accumulated to show the total pay out and balance for any period in the future (monthly, quarterly, yearly, etc.). It must as in the other elements of program management be dynamic. As project schedules and project funding levels are changed, these changes must be dynamically reflected in the cash flow projections. The cash flow segment must include not only the dynamic relationship of the project preconstruction and construction programs but must include payout profiles from the other areas of highway operations (maintenance, administration, etc) and Revenue sources.

Information available from the cash forecasting segment would include:

1) Cash payout by project and totals by specific time period for all projects in the plan.

2) Expected reimbursements from participating FHWA projects by project and all projects in the plan.

3) Cash payout for projects that have already been let and also projects that are to be let.

4) Actual project payouts compared to projected payouts for evaluation of payout curve accuracy.

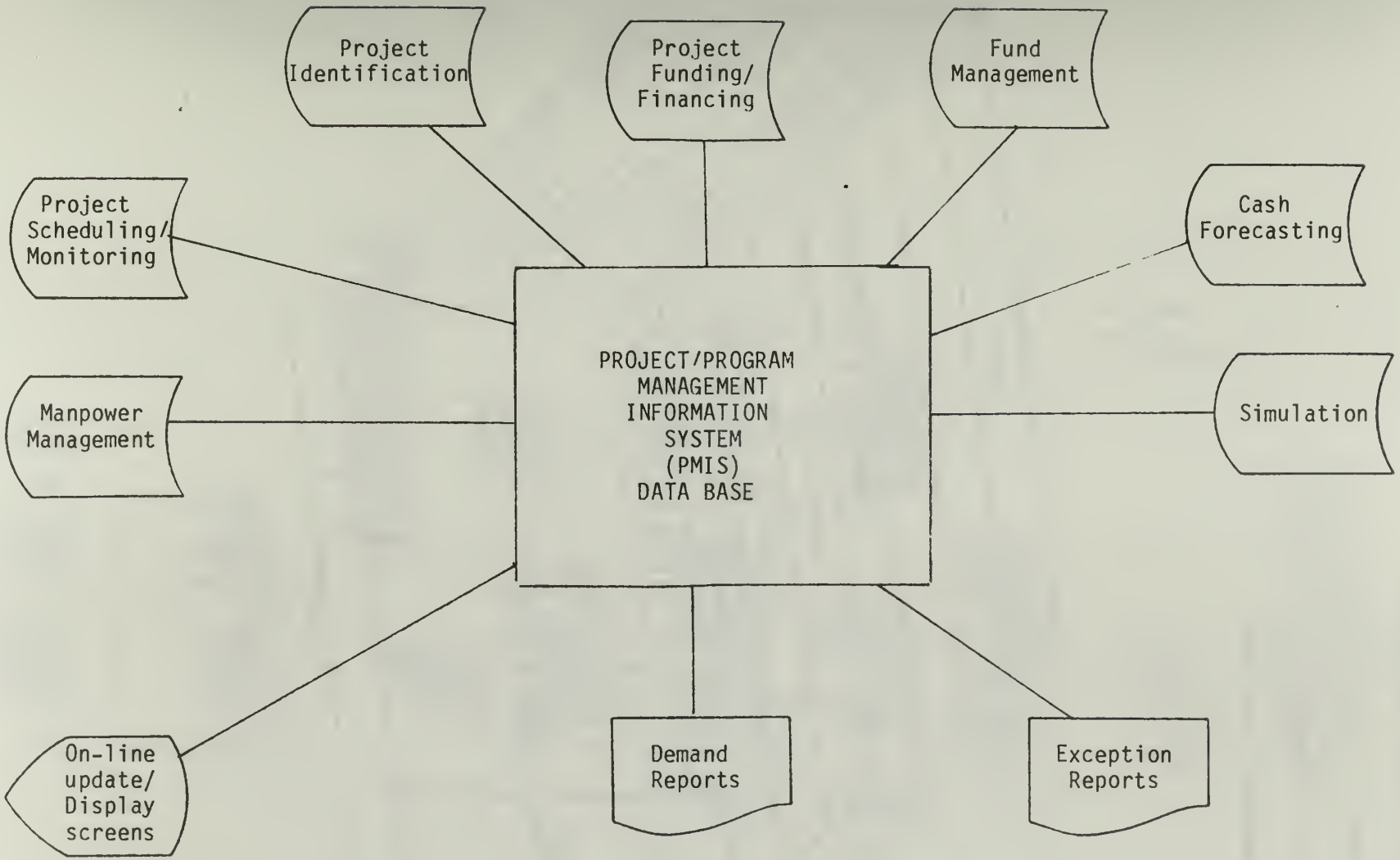
Simulation

The dynamic planning requirements of the department demand that the management system provide the users the capability to ask 'what if?' questions and predict the results of changes to project schedules, funding levels, resource requirements and availability, fund source amounts, etc. without actually making the changes to the actual data base. Simulation is the technique used to provide this capability. Facilities should be provided to:

- Add/delete projects to the schedule
- Change the letting date on existing projects
- Change the level of funding on existing projects
- Change the funding mix (reduce one fund source amount and increase another)
- Change the level of resources required

This process will enable the department to measure the effect of the above changes on Manpower Resources, fund balances and cash flow projections and to determine if they can be accomplished with existing resources before actually making the change.

A Project/Program schematic in general terms, a project phase/function relationship chart and a conceptual data element/data tree relationship for a Project/Program Information System are shown on the following pages.



Project Schedules
MP Req'ts/Available
Project Funding
Fund Source Status
Cash Forecasts
Simulation Processes

Work Program Status
Fund Source Status
Project Schedule
Activity Status
Planning Value Feedback
Resource Requirements
Resource Utilization

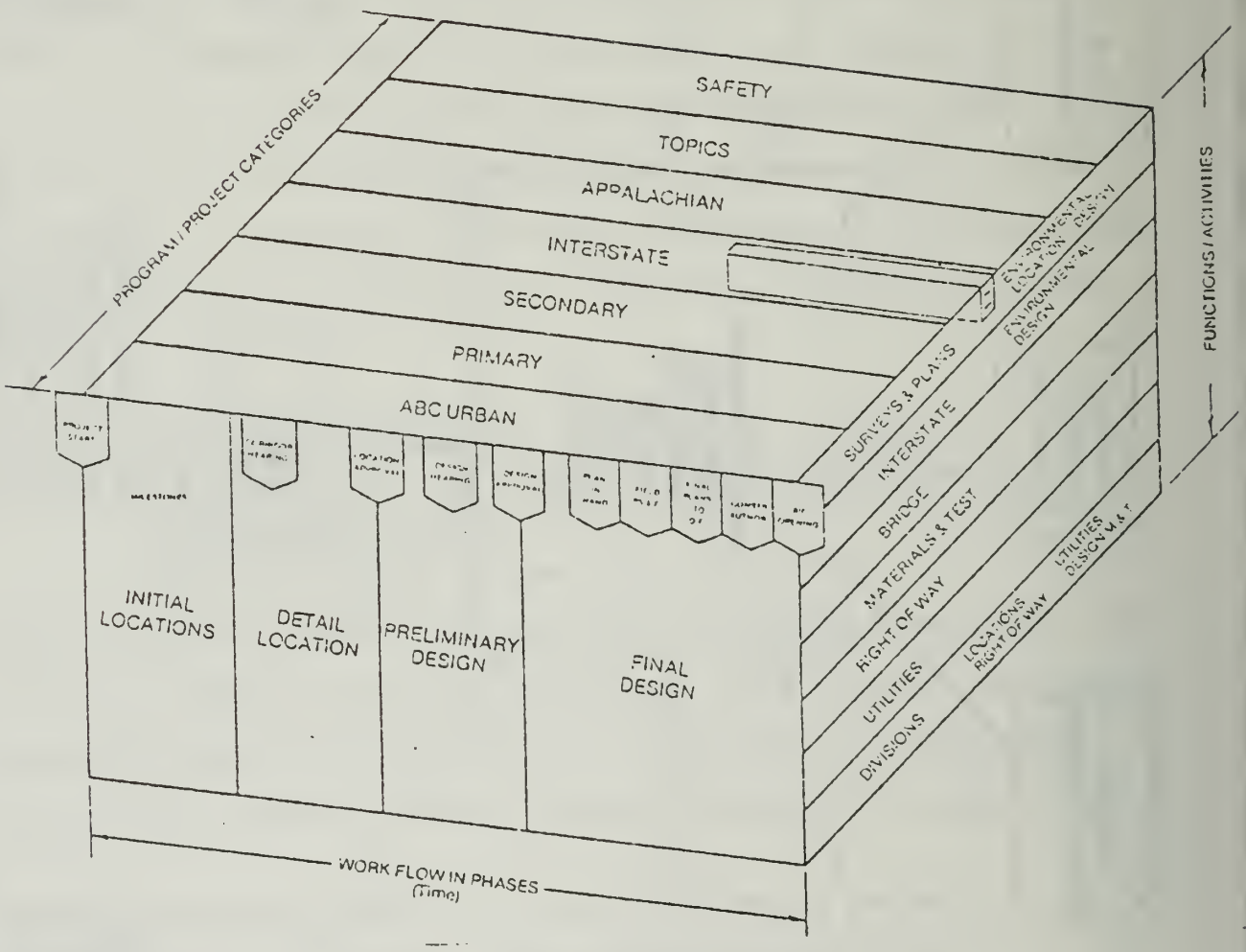
Milestones Missed
Scope Changes
Funding Exceeded
Funds to Lapse
ROW Clear
Letting Date Changed

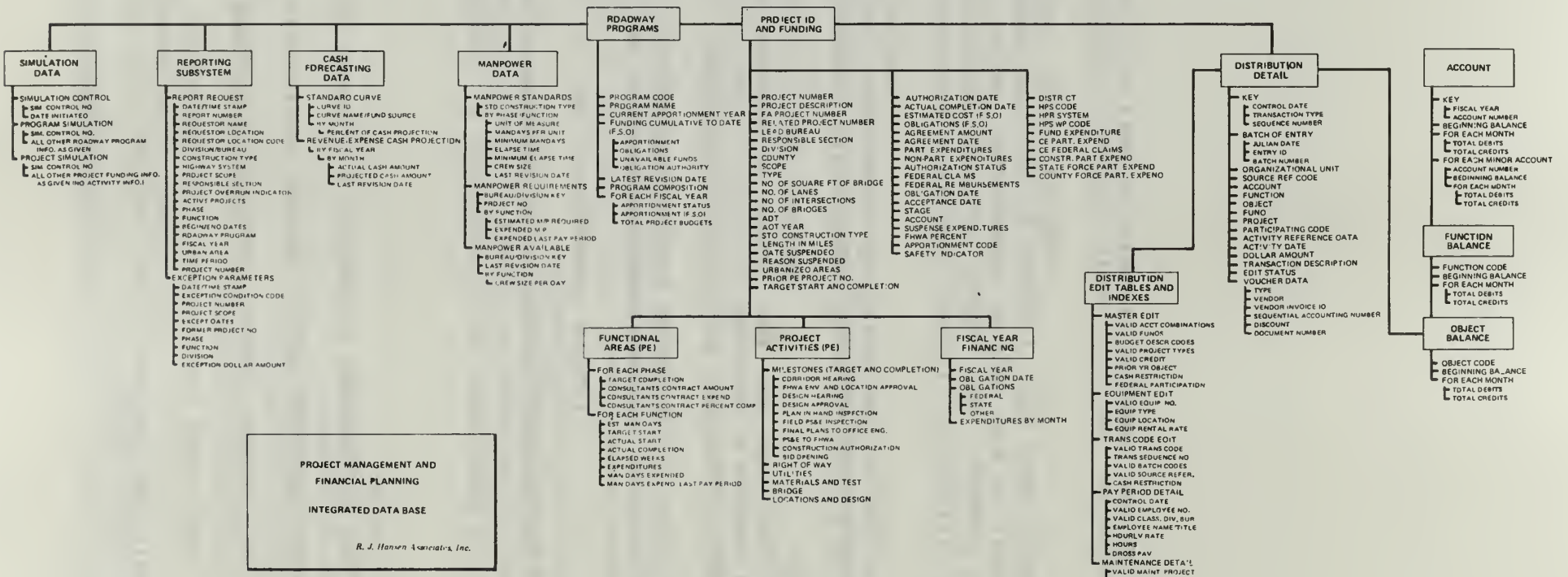
INTEGRATED PROJECT RESOURCES

+ FUNDS

+ TIME (Phases)

+ MANPOWER (Functions)




RDADWAY PRDGRAMS
PRDIECT ID AND FUNDING
SIMULATION DATA
SIMULATION CONTROL
SIM CONTROL NO
DATE INITIATED
PROGRAM SIMULATION
SIM. CONTROL NO.
ALL OTHER ROADWAY PROGRAM INFO. AS GIVEN
PROJECT SIMULATION
SIM CONTROL NO
ALL OTHER PROJECT FUNDING INFO. AS GIVEN INO ACTIVITY INFO.I
REPORTING SUBSYSTEM
REPORT REQUEST
DATE/TIME STAMP
REPORT NUMBER
REQUESTOR NAME
REQUESTOR LOCATION
REQUESTOR LOCATION CODE
DIVISION/BUREAU
CONSTRUCTION TYPE
HIGHWAY SYSTEM
PROJECT SCOPE
RESPONSIBLE SECTION
PROJECT OVERRUN INDICATOR
ACTIVE PROJECTS
PHASE
FUNCTION
BEGIN/END DATES
ROADWAY PROGRAM
FISCAL YEAR
URBAN AREA
TIME PERIOD
PROJECT NUMBER
EXCEPTION PARAMETERS
DATE/TIME STAMP
EXCEPTION CONDITION CODE
PROJECT NUMBER
PROJECT SCOPE
EXCEPT DATES
FORMER PROJECT NO
PHASE
FUNCTION
DIVISION
EXCEPTION DOLLAR AMOUNT
CASH FDRECASTING DATA
STANDARD CURVE
CURVE ID
CURVE NAME/FUND SOURCE
BY MONTH
PERCENT OF CASH PROJECTION
REVENUE-EXPENSE CASH PROJECTION
BY FISCAL YEAR
BY MONTH
ACTUAL CASH AMOUNT
PROJECTED CASH AMOUNT
LAST REVISION DATE
MANPOWER DATA
MANPOWER STANDARDS
STD CONSTRUCTION TYPE
BY PHASE/FUNCTION
UNIT OF MEASURE
MANDAYS PER UNIT
MINIMUM MANDAYS
ELAPSE TIME
MINIMUM ELAPSE TIME
CREW SIZE
LAST REVISION DATE
MANPOWER REQUIREMENTS
BUREAU/DIVISION KEY
PROJECT NO
BY FUNCTION
ESTIMATED M/P REQUIRED
EXPENDED M/P
EXPENDED LAST PAY PERIOD
MANPOWER AVAILABLE
BUREAU/DIVISION KEY
LAST REVISION DATE
BY FUNCTION
CREW SIZE PER DAY
PROGRAM CODE
PROGRAM NAME
CURRENT APPORTIONMENT YEAR
FUNDING CUMULATIVE TO DATE (F.S.O)
APPORTIONMENT
OBLIGATIONS
UNAVAILABLE FUNDS
OBLIGATION AUTHORITY
LATEST REVISION DATE
PROGRAM COMPOSITION
FOR EACH FISCAL YEAR
APPORTIONMENT STATUS
APPORTIONMENT (F.S.O)
TOTAL PROJECT BUDGETS
PROJECT NUMBER
PROJECT DESCRIPTION
FA PROJECT NUMBER
RELATED PROJECT NUMBER
LEAD BUREAU
RESPONSIBLE SECTION
DIVISION
COUNTY
SCOPE
TYPE
NO. OF SQUARE FT OF BRIDGE
NO. OF LANES
NO. OF INTERSECTIONS
NO. OF BRIDGES
ADT
ADT YEAR
STD CONSTRUCTION TYPE
LENGTH IN MILES
DATE SUSPENDED
REASON SUSPENDED
URBANIZED AREAS
PRIOR PE PROJECT NO.
TARGET START AND COMPLETION
AUTHORIZATION DATE
ACTUAL COMPLETION DATE
ESTIMATED COST (F.S.O)
OBLIGATIONS (F.S.O)
AGREEMENT AMOUNT
AGREEMENT DATE
PART. EXPENDITURES
NON-PART. EXPENDITURES
AUTHORIZATION STATUS
FEDERAL CLAIMS
FEDERAL REIMBURSEMENTS
OBLIGATION DATE
ACCEPTANCE DATE
STAGE
ACCOUNT
SUSPENSE EXPEND.TURES
FHWA PERCENT
APPORTIONMENT CODE
SAFETY INDICATOR
DISTRICT
HPS CODE
HPR SYSTEM
HPS WP CODE
FUND EXPENDITURE
CE PART. EXPEND
CE FEDERAL CLAIMS
CONSTR. PART EXPEND
STATE FORCE PART. EXPEND
COUNTY FORCE PART. EXPEND
FUNCTIONAL AREAS (PE)
FOR EACH PHASE
TARGET COMPLETION
CONSULTANTS CONTRACT AMOUNT
CONSULTANTS CONTRACT EXPEND
CONSULTANTS CONTRACT PERCENT COMP
FOR EACH FUNCTION
EST MAN DAYS
TARGET START
ACTUAL START
ACTUAL COMPLETION
ELAPSED WEEKS
EXPENDITURES
MAN DAYS EXPENDED
MAN DAYS EXPEND. LAST PAY PERIOD
PROJECT ACTIVITIES (PE)
MILESTONES (TARGET AND COMPLETION)
CORRIDOR HEARING
FHWA ENV. AND LOCATION APPROVAL
DESIGN HEARING
DESIGN APPROVAL
PLAN IN HAND INSPECTION
FIELD PS&E INSPECTION
FINAL PLANS TO OFFICE ENG.
PS&E TO FHWA
CONSTRUCTION AUTHORIZATION
BID OPENING
RIGHT OF WAY
UTILITIES
MATERIALS AND TEST
BRIDGE
LOCATIONS AND DESIGN
FISCAL YEAR FINANCING
FISCAL YEAR
OBL GATION DATE
OBL GATIONS
FEDERAL
STATE
OTHER
EXPENDITURES BY MONTH
DISTRIBUTION DETAIL
KEY
CONTROL DATE
TRANSACTION TYPE
SEQUENCE NUMBER
BATCH OF ENTRY
JULIAN DATE
ENTRY ID
BATCH NUMBER
ORGANIZATIONAL UNIT
SOURCE REF CODE
ACCOUNT
FUNCTION
OBJECT
FUND
PROJECT
PARTICIPATING CODE
ACTIVITY REFERENCE DATA
ACTIVITY DATE
DOLLAR AMOUNT
TRANSACTION DESCRIPTION
EDIT STATUS
VOUCHER DATA
TYPE
VENDOR
VENDOR INVOICE IO
SEQUENTIAL ACCOUNTING NUMBER
DISCOUNT
DOCUMENT NUMBER
DISTRIBUTION EDIT TABLES AND INDEXES
MASTER EDIT
VALID ACCT COMBINATIONS
VALID FUNDS
BUDGET DESCR CODES
VALID PROJECT TYPES
VALID CREDIT
PRIOR YR OBJECT
CASH RESTRICTION
FEDERAL PARTICIPATION
EQUIPMENT EDIT
VALID EQUIP NO.
EQUIP TYPE
EQUIP LOCATION
EQUIP RENTAL RATE
TRANS CODE EDIT
VALID TRANS CODE
TRANS SEQUENCE NO
VALID BATCH CODES
VALID SOURCE REFER.
CASH RESTRICTION
PAY PERIOD DETAIL
CONTROL DATE
VALID EMPLOYEE NO.
VALID CLASS, DIV, BUR
EMPLOYEE NAME TITLE
HOURLY RATE
HOURS
GROSS PAY
MAINTENANCE DETAIL
VALID MAINT PROJECT
VALID ACCT/FUNCTION
COMPLETED DATE
ACCOUNT
KEY
FISCAL YEAR
ACCOUNT NUMBER
BEGINNING BALANCE
FOR EACH MONTH
TOTAL DEBITS
TOTAL CREDITS
FOR EACH MINOR ACCOUNT
ACCOUNT NUMBER
BEGINNING BALANCE
FOR EACH MONTH
TOTAL DEBITS
TOTAL CREDITS
FUNCTION BALANCE
FUNCTION CODE
BEGINNING BALANCE
FOR EACH MONTH
TOTAL DEBITS
TOTAL CREDITS
OBJECT BALANCE
OBJECT CODE
BEGINNING BALANCE
FOR EACH MONTH
TOTAL DEBITS
TOTAL CREDITS
PROJECT MANAGEMENT AND FINANCIAL PLANNING
INTEGRATED DATA BASE
R. J. Hansen Associates, Inc.

IV. ALTERNATIVE APPROACHES

The purpose of this section is to present and discuss several alternative approaches for the Montana Department of Highways to implement a project schedule, manpower management and fund/cash management information system. Each approach provides a system with different levels of automated support to the Department Management.

Whatever approach is selected to be developed by the Department it is highly recommended that certain objectives be made an integral part of any development effort.

- Utilize a steering committee of users to participate and review the development efforts
- Keep the system mindful of the human resources and requirements involved (Develop a system that responds to user management needs, not one that requires users to respond to the system)
- Management Information Systems should be developed to support management decision making not to make these decisions.
- Information regarding actual utilization of resources (man power, project costs, etc.) should be provided to the Project Management System via an interface to the current accounting system. The same input source should support both systems.
- Information output from a project management system should be time related to support the budgeting process.

Alternative I
Develop and Implement a Full Project Management Information System (PMIS)

The elements from Section III involved in Alternative I include:

- Project Identification
- Project Scheduling/Monitoring (automated and manual)
- Manpower Management
- Project Funding/Financing
- Fund Management
- Cash Forecasting
- Simulation

Advantages

- System developed for specific needs of Montana Highway Department Management and to support existing management styles and requirements.

- Reduced operational costs compared to Alternative II because the system is developed for specific identified problems rather than a generalized approach.

- Voluminous batch reporting is reduced.

Disadvantages

- Increased development cost

Alternative II
Develop a Project Management System
Using the Current PC70/MMS as the Project Scheduling
and Manpower Management Segments

The elements involved in Alternative II are the same as Alternative I; however, some of the segments would not need to be developed because they are currently available in the PC/70 System. The elements from Section III involved in Alternative II include:

- Project Identification
- Project Scheduling/Monitoring
- Manpower Planning
- Project Funding/Financing
- Fund Management
- Cash Forecasting
- Simulation

The first three elements; Project Identification, Project Scheduling/Monitoring and Manpower Planning are available in the existing PC/70 System. The remaining elements; Project Funding/Financing, Fund Management, Cash Forecasting and Simulation systems would be developed to support the project management function.

Advantages

- Reduced development cost compared to Alternate I because the manpower and project schedule is provided by the PC 70/MMS package.

Disadvantages

- No on-line capability for projects -

  Projects are identified, scheduled and resources are identified in a batch mode. No on-line inquiry or update capability exists. It could be provided for these segments using the PC/70 system by either purchasing the on-line portion of the system from the PC/70 vendor or modifying the system in use currently with MDOH computer staff.

- Increased operational costs

  Because the PC/70 system was developed as a general approach to satisfy project management and scheduling requirements for a multitude of project types other than highway construction projects it is very expensive in computer resources.

- On-line simulation capabilities would be limited to fund balances and cash flow projections unless the present system was modified as explained above.

- Two project management systems would have to maintained. Conceptually you can interface the various segments but it is operating in two segments (one on-line the other batch). Different operating procedures would need to be employed.

Alternative III
Research and Review other Project Management Systems from other states to determine if any meet the requirements of MHD.

This alternative would consists of a survey of all states or other government agencies that are currently using an automated Project/Program Management information system for the purpose of transferring the system as developed to MDOH. Some states where a survey of this nature could begin would be:

New Mexico
Idaho
Iowa
Minnesota
Alabama
FHWA System that is under development

Advantages

- Reduced development time (if the system could be transferred as is)
- Reduced development costs
  Some development costs could not be avoided

Disadvantages

- Generally systems are developed specifically for the user and certain system characteristics cause alternate users to modify their management practice to fit the system.
- Because different states usually have different computer systems (either hardware or software variances) transferability of systems is difficult. Usually if the system's programs must be modified to operate on another computer, another telecommunications monitor or another database management system it is more feasible to write the programs new than to undertake an extensive modification effort.
- There have been many attempts by various agencies to accomplish this transfer concept with limited success.

In the experience of the consultant the complete transferability of systems is not a feasible alternative. The user generally obtains a system that is less than what is desired and costs to perform the surveys, transfer and modify the programs, etc. are not negligible. Transferring concepts of a system from one agency to another has been performed successfully on many occasions but there is generally a considerable amount of redesign of the details and a complete rewrite of the programs.

Alternative IV
Use PC70/MMS currently being developed and forego the cash forecasting, fund management and simulation function capabilities

This alternative involves the continued development of the process currently being performed by the project control staff.

The elements from the Section III involved in Alternative IV include:

- Project Identification
- Project Scheduling/Monitoring
- Manpower Management

Advantages

- No additional development costs other than development process being performed currently.
- The system could be operational sooner than other alternatives.

Disadvantages

- It does not provide the information necessary to manage the MDH processes.

In the opinion of the consultant, it is not a viable alternate because it does not provide the level of information necessary to manage the highway construction program. It is identified here because it is a valuable information source and will provide the base from which to establish and implement the management information system selected to be used by the Montana Highway Department.

Alternative V
Use PC70/MMS currently being developed
and forego the cash forecasting
and simulation function capabilities

This alternative involves the continued development of the process being performed by the Project Control staff with some minor modifications to the scheduling process and developing the project funding/financing and fund management subsystem to supplement the current Project Management System.

The elements from the Section III involved in Alternative V include:

- Project Identification
- Project Scheduling/Monitoring
- Manpower Management
- Project Funding/Financing
- Fund Management

The first three elements; Project Identification, Project Scheduling/Monitoring and Manpower Planning are available in the existing PC/70 system. Some evaluation and modification is recommended to make them responsive to the Preconstruction Management user needs. The remaining elements; Project Funding/Financing and Fund Management systems would be developed to support the project programming function.

Advantages

- Provides the most critical information to the Department that is currently lacking at the least cost.
- Makes maximum use of current PC/70 system.

- Significant reduction in development costs (in relation to alternatives I or II).
- The system could be operational sooner than alternatives I or II.

Disadvantages

- Does not provide a total integrated Project Management System.

Evaluation and Modification to PC/70

- Establish a steering committee of users to support the development effort.
- Pinpoint the critical task dates to reflect the needs of management.
- Determine scheduling requirements necessary to support the ROW function.
- Determine on-line requirements.
- Expand PC/70 use to include construction engineering and ROW activities and time.
- Determine procedure for reporting project status (ahead or behind schedule).
- Develop and implement training plans for users.
- Expand Project Control Manpower Management User Guide document.
- Determine additional reporting requirements for Manpower Management and project status.
- Establish and follow procedures for identifying, controling and modifying project schedules.
- Adopt a unique project number to be used as a primary identifier on the computer file (both PC/70 and PMIS).
    + This number should not replace or change the project numbering system currently adopted by the Department.
    + This number should provide uniqueness, i.e., no two projects with the same number.

+ This number should be used to identify one project for all stages (PE, ROW and Construction).

+ The number should not be dependent on the funding source, it should not require that the identification of the project be changed if the method or source of funding changes.

Recommendation

It is the recommendation of the committee and the consultant that Alternative V be selected for the following reasons:

- Uses the current PC/70 system which the Department has a considerable investment.
- Provides the most critical information that is currently needed.
- Can be developed in the near term without placing an unrealistic burden on MDOH's finances or manpower.
- Can be developed in a modular fashion so that either Alternative I or II could be accomplished in the long range plan if so desired.
- The system could be operational less than one year from the start of development.

IV. DEVELOPMENT PLAN AND SYSTEM BENEFITS DEVELOPMENT PLAN

This section will outline a plan for the MDOH to accomplish the development of a Project/Program Management Information System (PMIS). This plan will be developed around Alternative V from Section IV, however, most of the concepts of the plan would apply to any information system selected by the Department. The time and cost estimates could vary depending on the size and extent of the development effort of the system to be designed and implemented.

Development Plan for Alternative V from Section IV

This development approach assumes selection of alternative V from the previous section (Report Section IV).

General Design	3 months
Detail Design	2 months
Programming and Implementation	5 months

Development Operational Costs

The cost to develop PMIS for alternatives I, II and V from Section IV is presented. The costs presented are shown in manday estimates and associated dollar costs. The estimates are made assuming consultant performs the General Design, Detail Design and manage the programming and MDOH data processing to perform the programming and implementation. Any variation of this approach could be determined by shifting mandays from consultant total to MDOH DP staff total. It is the recommendation of the consultant that outside assistance be obtained at least for the General and Detail Designs because specific expertise in developing these type systems can be provided that may not be available within the MDOH data processing staff. Also this approach would provide substantial time savings in the total system development effort which appears to be a major consideration of the department. This approach was suggested and approved by the Chief of the Data Processing Bureau for MDOH.

Alternative I

Development Cost

	MD's	COST
MDOH Staff (non Data Processing)	500	75,000
MDOH Data Processing Staff	800	128,000
Consultant	700	245,000
Computer Costs (Programming/Testing)		100,000
		548,000

Operational Costs

DP Support	20,000/yr.	
Hardware/Software/Terminals	25,000/yr.	
Computer Processing	25,000/yr.	
	70,000/yr.	
8 - year operating costs		560,000
Total 8 - year system cost		$1,108,000

Alternative II (low estimate)

Development Cost

	MD's	COST
MDOH Staff (non Data Processing)	500	75,000
MDOH Data Processing Staff	536	85,760
Consultant	470	164,500
Computer Costs (Programming/Testing)		100,000
		425,260

Operational Costs

DP Support	20,000/yr.	
Hardware/Software/Terminals	25,000/yr.	
Computer Processing	27,500/yr.	
	72,500/yr.	
8 - year operating costs		580,000
Total 8 - year system cost		$1,005,260

Alternative II (high estimate)

Development Cost

	MD's	COST
MDOH Staff (non Data Processing)	500	75,000
MDOH Data Processing Staff	600	96,000
Consultant	525	183,750
Computer Costs (Programming/Testing)		100,000
		454,750

Operational Costs

DP Support	20,000/yr.	
Hardware/Software/Terminals	25,000/yr.	
Computer Processing	30,000/yr.	
	75,000/yr.	
8 - year operating costs		600,000
Total 8 - year system cost		$1,054,750

In both cost estimates for Alternative II the development costs are lower than for Alternative I. This is because part of the total system would include the PC/70 package system which is already developed. Also both estimates for this alternative show higher operating costs. This is because, as pointed out in Section IV, the PC/70 system is an all purpose system designed to perform all functions for all users and consequently is very expensive in computer resources.

Alternative V

Development Cost

	MD's	COST
MDOH Staff (non Data Processing)	250	37,500
MDOH Data Processing Staff	420	67,200
Consultant	280	98,000
Computer Costs (Programming/Testing)		20,000
		222,700

Operational Costs

DP Support	5,000/yr.
Hardware/Software/Terminals	6,000/yr.
Computer Processing	6,000/yr.
	17,000/yr.

8 - year operating costs	136,000
Total 8 - year system cost	$358,700

No development costs have been included for alternatives III and IV. The development cost for alternatives III would depend entirely on the extent of the research and review of other systems and the extent of the modifications that may be required to the acquired system to make it functional for MDOH. There would be no increased development cost for alternative IV because no new extensive development effort would be involved. It would merely be a continuation of the development effort currently being performed in Project Control.

SAVINGS AND BENEFITS

Implementing the recommended Preconstruction Management System will result in productivity improvement from the following factors:

+ Stability of work program.
+ Clear definition of work.
+ Role in accomplishment goal setting.
+ Timely decision making.
+ Reasonableness of work load.
+ Communication.

These factors all provide a savings but taken individually are nonquantifiable. Taken as a whole, the total productivity of the Department attributed to scheduling systems will result in a savings that would amount to from $200,000 to $300,000 per year.

The following are benefits provided by a new Decision-Making Process and PMIS that firmly support the recommendations of this report.

- Identify various projects collectively as work programs, meeting a specific set of objectives.
- Determine, before commitment is made, resources (time, manpower, funds) required to complete a project or accomplish an entire work program.
- Determine availability of resources needed to complete work programs.
- Monitor and report progress toward completion of defined projects and work programs.
- Report status, both financially and physically, of all projects in the work program.
- Schedule and reschedule projects within the multi-project work environment.

- Utilize planning values for developing schedules, planned accomplishment, and resource requirements.
- Provide feedback as to actual results on accomplishment and to planning values.
- Allow changes to be made in a simulation mode to provide information to "what it" questions or alternatives.

OM:mb:208E

R.J. HANSEN ASSOCIATES, INC.

MANAGEMENT AND INFORMATION SYSTEMS CONSULTANTS

SUPPLIES AND MATERIALS MANAGEMENT INFORMATION NEEDS ANALYSIS

FOR THE

DEPARTMENT OF HIGHWAY
STATE OF MONTANA

July 1981

SUPPLY AND MATERIALS

SYSTEM CONCEPTUAL DESIGN

STATE OF MONTANA

DEPARTMENT OF HIGHWAYS

JULY, 1981

Steering Committee:
P.E. Thompson, Manager - Inventory Control
Dick Rogers, Chief - Equipment Fiscal Bureau
Orville Johnson, Admin. Officer II
Bill Swanton, Analyst

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I. INTRODUCTION

In an effort to better manage material inventories and adequately plan for future requirements, the Department of Highways is conducting a review of current Departmental procedures. This report provides an analysis of current practices in the management of the Department's inventories, and identifies recommended system changes for improving inventory control.

1. Summary of Recommendations

- To clarify channels of communications, all functions of Stores operation need to be organized under a singular controlling body with full time management.
- Inventory budgeting should be based on future anticipated needs instead of historical usage.
- All recommendations in prior studies are still desireable.
- In the support system, several enhancements were identified such as:
  - Interface with Equipment and Maintenance management operations.
  - Provide unit prices, reorder levels, location of stocks, etc.

2. Background and Objectives

The Department of Highways maintains a number of warehouses containing dispensible inventories of suppliers in support of the operations of equipment management and road maintenance. The management of the inventories is currently under the jurisdiction of the Department's Accounting Division while the daily operations of the inventories is handled by the user Bureaus - Equipment and Maintenance. The anticipated budget for on-hand supplies is $13.3 million for the 1982 budget year and is expec-

ted to increase to $14.5 million in 1983. With today's high cost of capital, good inventory control and minimum inventory investment is essential.

Prior studies of potential information system improvements have been conducted with the objectives of reducing the manual effort and of improving accountability controls. One such study was conducted in April 1978 by R.J. Hansen Associates. This study documented the Department's Warehousing operations and practices and concluded that manual and automated procedural improvements would be cost effective. Specific observations noted in the study were:

". Guidelines Documentation - Warehousing practices were outlined several years ago, and do not meet current needs for documented statewide guidelines. As a result, warehousing practices have been inconsistently and individually augmented by stockmen. Although many of the practices are independently sound, inconsistency on a statewide basis precludes effective overall controls. Statewide guidelines should be developed to enhance controls and to provide a needed training medium. Guidelines should specifically address the following practices:

+ Issue policy
+ Determination of surplus or obsolete stock and associated procedures for disposition.
+ Pricing policy
  - moving average
  - discounts
+ Accounting for variances and shortages
+ Revolving Fund methods

- Physical Inventory - Stock levels in the Stores Inventory System master file are updated annually through a continuous process by which selected items are counted each month. This staggered physical inventory process smoothes the work load but may be counter-productive in view of the occurrence of audit exceptions. The merits of a year-end physical inventory process should be re-examined to determine more frequent needs for high turnover expensive items.

- Storage Facilities - Despite limited available space, stockmen have adapted well in establishing relatively secure storage, especially for critical high-loss items. However, accountability for many items is difficult to establish since stores are frequently spread in numerous locations with varying degrees of access by others depending upon the criticality of need. Specifically in relation to central stores facilities, there is presently insufficient access for lift truck and archives are crowding office supplies. A plan should be developed for the move to the new facilities to assure allowance for archives and an effective item location scheme. Only a well organized storage facility will allow effective controls. All physical storage facilities should be reviewed in conjunction with the development of warehousing practice guidelines to minimize the impact of existing limited storage facilities.

- Out-of-Stock Conditions - Few out-of-stock conditions cause issue requisitions to be unfilled.

The existence of a high fill-rate reflects a good inventory service level but raises the question of being overstocked. In general inventory practice, it has been determined that to raise a fill-rate from 65% to 90% (out-of-stock 10% of the time) increases the inventory level by 81%. Accurate volume flow statistics are needed to determine if overstock conditions exist.

- Obsolescense - The current procedures for handling obsolete or surplus items are not universally understood. Significant quantities of stock items remain unused. The current practice of transferring surplus items into suspense ("7000 area") lacks controls. Obsolescence could be reduced by:
  + Monitoring slow-moving items
  + Establishing Surplus Return procedures and contract clauses
  + Anticipating changing item requirements
  + Implementing recommended order quantities
  + Modifying annual purchases or allowing split shipments.

- Personnel - Each of the stockmen interviewed appeared conscientious and have developed individual practices to overcome many system limitations. However, current organization and pay scale have been suggested as contributing factors to the lack of motivation and the turnover of stockmen. The organization and payroll aspects of the stockman position should be reviewed and upgraded as appropriate to achieve the desired level of accountability."

Subsequent systems development work resulted in the publication of a General Design for a Stores Inventory Management System and Remote Division Processing System (September 1978). The document made the following recommendations.

"Six policy and practice areas were identified for potential change as recommended below.

- Annual Purchasing - Under the current purchasing policies of the State of Montana many supplies are requisitioned and purchased only once each year. Since the purchases are made by the State Purchasing Department, each agency notifies the purchasing agent of the agencies need for the coming year, and the total State needs are combined in one purchase order.

  The advantages of this type of purchasing are:
  + Lower per unit cost
  + Reduced cost of processing orders.

  The disadvantages are:
  + Cost of lost opportunity for money tied up in supplies
  + Increased storage costs
  + Increased cost in handling supplies
  + Increased loss due to obsolescence
  + Decreased control for storage of high value (or high pilferage) items.

  The disadvantages of annual purchasing far outweigh the advantages. Wherever possible, open state contracts would be preferable to annual purchases. If State law is such that annual purchases are required, partial deliveries could achieve benefits similar to more frequent purchasing.

- Stocking Levels - Research, conducted in June 1978, indicated that of the various items stocked, over half are never, or very seldom used. This was determined by counting each different stock item at each supply location and checking the last date of issue. Items were counted only if the date was less than a year old. The percentages of items stocked and used within the past year ran from 22% to 48%.

  Items which are carried in stock but seldom used, should be brought to the central stores facility for stocking or they should be removed from inventory. It is recognized that certain emergency items must be stocked even though they are seldom or never used. However, each low movement item should be evaluated to determine if it can be locally purchased in an emergency situation. In all cases, non-emergency items which are seldom used should be removed from the inventory.

- Open State Contracts - Many items are purchased open state contracts. These contracts call for items to be supplied to the Department at a pre-arranged price or at current market prices with a fixed discount rate. Open purchasing methods have the major benefit of buying supplies at a known price only when they are needed.

  It was noted, however, that there is little or no control when dealing with some vendors. No purchase order was created, no copies of the vendors order sheets were retained, and no notification was given to the storekeeper.

  While open state contracts are an excellent method of purchasing, they should be controlled as rigidly as a normal purchase. One method of providing this control would be to create a local purchase order for every open contract pur-

chase. This could be entered into the SIMS (Stores Inventory Management System) and would appear as a receiver to the stockman who will be receiving the supplies. This would also provide the same audit trail that other purchases provide.

- Staffing - Current staffing consists of one Stockman in each Division and two at Central Stores. The stockmen at the Divisions report to the Shop Foreman and are among the lowest paid employees. As a result, most stockmen apply for better paying positions whenever possible creating a high turnover.

  The Stockman should not report to the Shop Foreman, but rather to the Division Administrative Officer I. The Stockman provides a service to everyone in the Division, and therefore, should not report in the line of only one section. Serious consideration should be given to upgrading the Stockman position to a higher pay grade. Reduced turnover and better warehouse facility operation would result.

  A position of Inventory Coordinator is recommended at the headquarters in Helena. This individual would review stocking levels, inter-division transfers, local purchasing, monies spent against open contracts, etc.

  If possible he should be appointed as a purchasing agent for the Department of Highways with the authority to create purchase orders up to $5,000. He could also provide training for Division Stockman which would result in common procedures statewide.

- Facilities - Facilities, both at Helena and at the various Divisions, are not adequate to provide complete control of supplies. Stock is located in multiple storage locations,

often at a relatively large distance from the main storeroom. The result is people waiting for the Stockman, people taking their own supplies, and often, difficulty in locating the Stockmen to issue parts and supplies.

While it is recognized that facilities are poor, it is also recognized that only a massive rebuilding project could totally correct the problem. The problem will be reduced if the inventory levels are reduced, if the storage problems caused by annual purchasing and inadequate stock level control are eliminated, and if the stockmen themselves initiate a reorganization of the stock to maximize the facilities available.

- Yard Security - Currently there is uncontrolled access to inventory in the yards at some Divisions. Inventory can be brought into or taken out of the yards without the Stockman's knowledge, thereby bypassing inventory record updates and control. It is vital to maintain inventory record accuracy since it is the basis for purchasing and material transfer decisions.

  Control procedures must be set up for all Divisions to ensure that all inventory brought into the yards is authorized and the stockman is aware of all such movement. Remote stockpiles will remain a problem to control."

  Of the recommendations listed, only the creation of an Inventory Coordinator and the upgrade of the stockmen has been adopted by the Department.

The study also identified an automated Stores Inventory Management System (SIMS) that, by design, would provide

- Inventory Planning
- Movement (transfers) planning
- Order processing
- Statistical Maintenance
- Status Monitoring

The automated system is in the process of being implemented throughout the State. Initial conversion of inventory data was accomplished in April; however, diligent use of the system is required in order to improve the accuracy of the data and place the system into full production.

The objective of this report is to identify additionally desired improvements in the stores operations and to conceptually design the integration of the SIMS system into the Department's overall management information system requirements.

II. SUMMARY OF CURRENT PROCEDURES

The identified problems of the current stores operations are presented here.

1. Organization

Inventories of dispensible items are warehoused centrally, in each of the eleven divisions, and in the maintenance sections. For accounting purposes stores items are categorized as follows:

Inventory Account	Description	Responsible Bureau
1310	Gravel Stockpiles	Field Maintenance
1330	Office & Engr. Supplies	Inventory Control
1340	Road Oil Storage	Field Maintenance
1350	Equip. Parts & Supplies	Fiscal & Equip. Supply
1360	Construction & Maint. Supplies	Field Maintenance
1370	Laboratory Supplies	Accounting

The current organizational chart shown in Exhibit 1 reflects this categorization of inventories. Responsibility for the Equipment Parts and Supplies Inventory belongs to the Fiscal and Equipment Supply Bureau, responsibility for the Construction and Maintenance Supplies, Road Oil and Gravel Stockpiles belongs to the Field Maintenance Bureau, and the responsibility for Laboratory, Office and Engineering Supplies belongs to the Accounting Bureau. Recent development of the Stores Inventory Management System prompted the implementation of several of the policy recommendations sited in prior studies. The position of Inventory Coordinator has been established

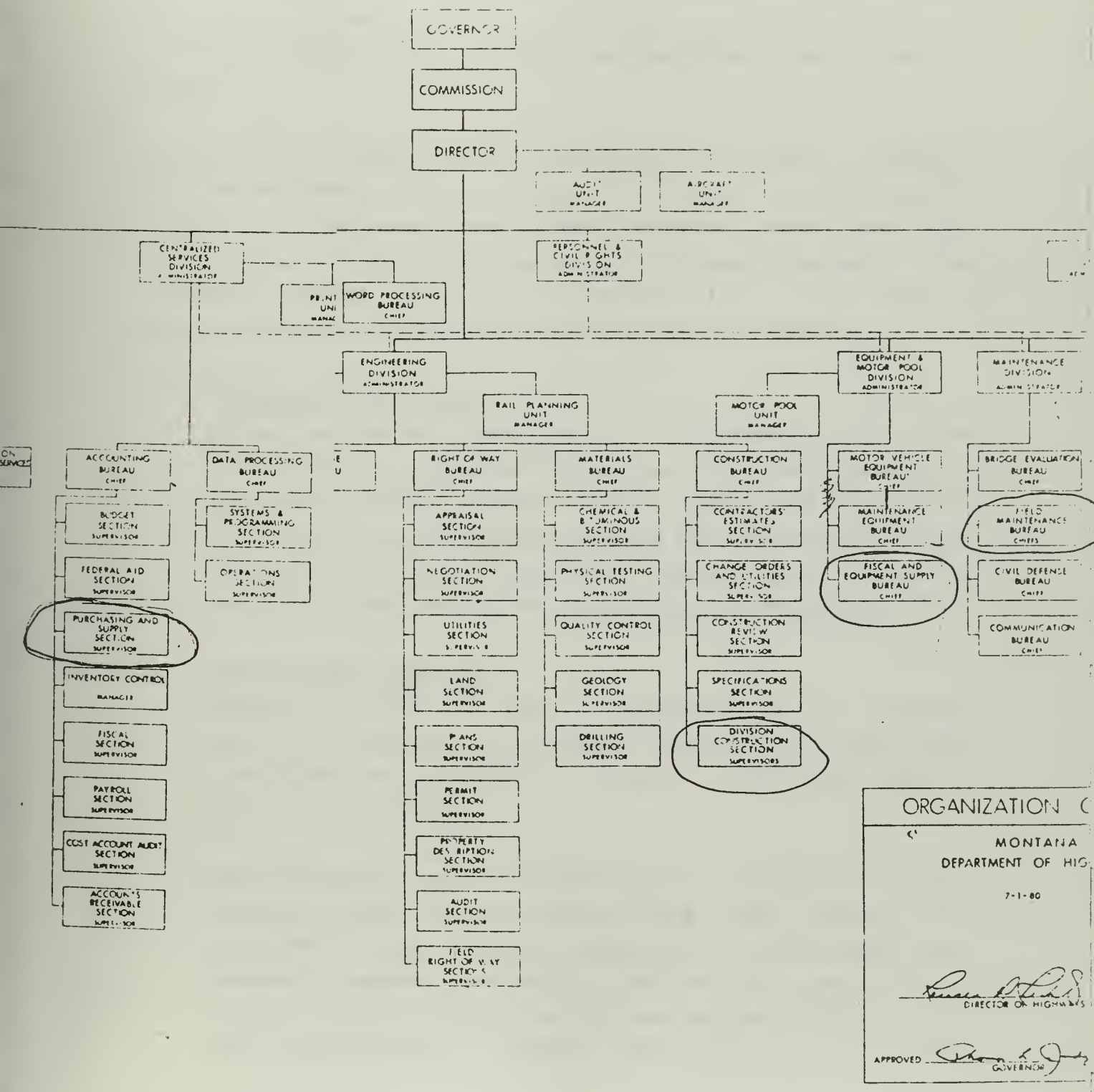

GOVERNOR
COMMISSION
DIRECTOR
AUDIT UNIT MANAGER
AIRCRAFT UNIT MANAGER
CENTRALIZED SERVICES DIVISION ADMINISTRATOR
PRINT UNIT MANAGER
WORD PROCESSING BUREAU CHIEF
PERSONNEL & CIVIL RIGHTS DIVISION ADMINISTRATOR
ENGINEERING DIVISION ADMINISTRATOR
RAIL PLANNING UNIT MANAGER
EQUIPMENT & MOTOR POOL DIVISION ADMINISTRATOR
MOTOR POOL UNIT MANAGER
MAINTENANCE DIVISION ADMINISTRATOR
ACCOUNTING BUREAU CHIEF
BUDGET SECTION SUPERVISOR
FEDERAL AID SECTION SUPERVISOR
PURCHASING AND SUPPLY SECTION SUPERVISOR
INVENTORY CONTROL MANAGER
FISCAL SECTION SUPERVISOR
PAYROLL SECTION SUPERVISOR
COST ACCOUNT AUDIT SECTION SUPERVISOR
ACCOUNTS RECEIVABLE SECTION SUPERVISOR
DATA PROCESSING BUREAU CHIEF
SYSTEMS & PROGRAMMING SECTION SUPERVISOR
OPERATIONS SECTION SUPERVISOR
RIGHT OF WAY BUREAU CHIEF
APPRAISAL SECTION SUPERVISOR
NEGOTIATION SECTION SUPERVISOR
UTILITIES SECTION SUPERVISOR
LAND SECTION SUPERVISOR
PLANS SECTION SUPERVISOR
PERMIT SECTION SUPERVISOR
PROPERTY DESCRIPTION SECTION SUPERVISOR
AUDIT SECTION SUPERVISOR
FIELD RIGHT OF WAY SECTION SUPERVISOR
MATERIALS BUREAU CHIEF
CHEMICAL & BITUMINOUS SECTION SUPERVISOR
PHYSICAL TESTING SECTION SUPERVISOR
QUALITY CONTROL SECTION SUPERVISOR
GEOLOGY SECTION SUPERVISOR
DRILLING SECTION SUPERVISOR
CONSTRUCTION BUREAU CHIEF
CONTRACTORS' ESTIMATES SECTION SUPERVISOR
CHANGE ORDERS AND UTILITIES SECTION SUPERVISOR
CONSTRUCTION REVIEW SECTION SUPERVISOR
SPECIFICATIONS SECTION SUPERVISOR
DIVISION CONSTRUCTION SECTION SUPERVISORS
MOTOR VEHICLE EQUIPMENT BUREAU CHIEF
MAINTENANCE EQUIPMENT BUREAU CHIEF
FISCAL AND EQUIPMENT SUPPLY BUREAU CHIEF
BRIDGE EVALUATION BUREAU CHIEF
FIELD MAINTENANCE BUREAU CHIEFS
CIVIL DEFENSE BUREAU CHIEF
COMMUNICATION BUREAU CHIEF
ORGANIZATION
MONTANA
DEPARTMENT OF HIG
7-1-80
DIRECTOR OF HIGHWAYS
APPROVED
GOVERNOR

EXHIBIT 1

within the Accounting Bureau to provide for the coordination of stock movement among the field divisions. (See attached job description.) The coordinator is responsible for reviewing stock levels and filling Division requisitions for stock.

The Division organizational structure is depicted in Exhibit 2. The stockmen are responsible for the day-to-day operation of the Division warehouse. They receive, store, and issue inventories for the Maintenance and Equipment Bureaus. The stockmen however have line responsibility to the Central Accounting Office and not to the bureaus they serve.

a. Management Practices

Under the current organizational structure, there is an overlapping of responsibility for the stores operation, and, as a result, control over the operation is lacking. This lack of control has spawned the inefficient stock-piling of inventories and item obsolescence. Lines of authority for control over inventory is ambiguous.

b. Operational Functions

Because of lack of timely information as to financial position, current procedures require that Department operations be suspended at the end of the fiscal year to avoid cost overruns.

Operationally, each Division has a computer terminal through which stock requisitions and receipts are recorded. The computer terminal is sometimes not, however, located physically near the inventory and as a result, stock record keeping has become a function of the office clerk. Records are collected on a daily

basis at the Divisions and routed nightly to the Central Stores Accounting System. The inventory coordinator reviews all requisitions and determines how it can best be filled -- either by transfer from another division or by purchase. The inventory coordinator is responsible for initiating the movement of the stock to the requesting Division. This process can at times take up to three days to complete. Time pressures sometimes cause stock to be purchased locally when in fact they may be on hand at other Divisions.

The stockmen also perform physical counts on their own inventories. Past experience has demonstrated that these counts can be inaccurate. Familiarity with the inventory may cause oversights of unused items.

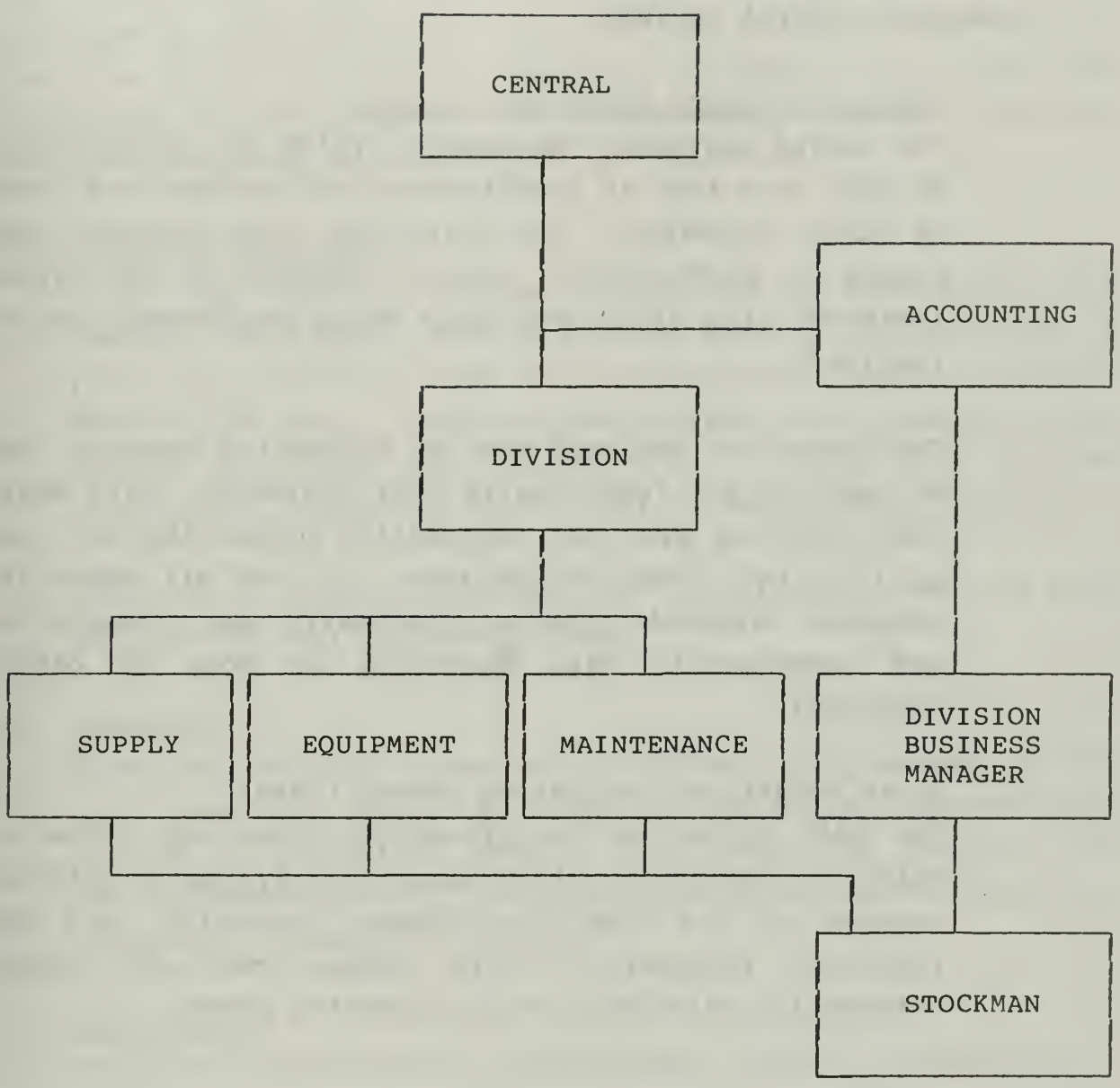
The stockman position has historically experienced a high turnover of personnel. The salary structure of other Department positions attract the stockman and can have a negative incentive on commitment to the stock functions.

c. Decision Processes

The inventory coordinator is responsible for the management of the movement of stock among the Divisions.

He is not, however, responsible for the inventories he manages. As a result, the communication between the Divisions and user Bureaus is non-existent. Decisions to purchase inventory are made by the User Bureaus oft times due to lack of information, cooperation, and timeliness of acquisition.

EXHIBIT 2



CURRENT DIVISION ORGANIZATION

2. Support Systems

The supply procedures interface with automated accounting and inventory control systems.

a. Stores Inventory Management System

The Stores Inventory Management System was developed to be used as a tool in coordinating the purchase and issue of stock statewide. The system has just recently been placed in production. Initial exposure to the system indicates that there are areas where improvement can be realized.

The System was designed from an accounting approach, and as such is not functionally user oriented. Data entry functions are slow and requisition processing can take up to 2 to 3 days to complete. In not all cases are computer terminals located physically near inventories and consequently data recording is done by office personnel.

b. State Budget and Accounting System (SBAS)

The SBAS System is the statewide accounting system to which the Stores Inventory Management System interfaces. Because of the time lag between recording data and reporting information, this system does not provide information coincident to management's needs.

III. ANALYSIS OF NEEDS

The predominant theme running through the steering committee meetings is that there is a lack of accountability and control over the stores operation. Numerable recommendations have been identified in past studies that are recognized as desirable but that have not been implemented by the Department.

1. Organizational Needs

   To clarify channels of communication and increase cooperation among the Divisions, Bureaus and Accounting, all functions of the Stores operation need to be re-organized under a singular controlling body. Organizational purpose and objectives must clearly be stated and communicated. Policy must also be established, communicated and just as importantly, enforced.

   Channels of communication must be identified as well as procedures for conflict resolution.

2. Planning

   To better anticipate realistic inventory requirements, inventory budgeting should be based on future anticipated needs instead of historical usage. This should be feasible with the implementation of the Maintenance Management & Equipment Management Information Systems.

3. Operational

   Recommendations made in prior studies are still desirable.

   - Develop state-wide guidelines to enhance inventory control.
     + Standardize procedures for handling obsolete or surplus items. Insufficient communications about current technological advances has led to the con-

sistent purchasing of technically obsolete tools, or parts for equipment being phased out of State service.

+ Increase central control over division inventories by providing central authority to move the inventory where needed.
+ Upgrade the Inventory Coordinator position to the same level as the internal auditing section.
+ Give Inventory Coordinator authority to exercise control.

- Physically locate the Division's computer terminal in the Parts Room.
- Provide better access to inventory coordinator by divisions.
- Tighten security at inventory storage facilities.
  + Improve accuracy of inventory accounting at gasoline storage facilities.
- Implement a team approach to taking physical inventory at inventory storage locations. An independent count by inventory knowledgeable people or cross check of manually prepared inventory counts can improve reliability of information.
- Adopt a Centralized Purchasing Policy.
  + Allow Highways to purchase inventory up to a prescribed limit ($2,000) without going through the State purchasing agent. This will enhance the timeliness of purchases.
  + Implement an on-going process of purchase review.
  + Streamline the Bid Specification procedure.
    - Allow the originating department to review the final Bid Specifications before they are distributed.
    - Allow the specification of brand names with no

substitution. This will increase long term use of items and will reduce recurrence of obsolescence.

- Establish standard items in stores and eliminate special purpose items.
- Enforce policy.
- Place stores inventory under a singular Stores Operation organizationally to establish accountability.
- End user must be accountable for use of stock once it is charged out of stores. User must tell the Stockman the project and activity to which the cost must be transferred.
- Utilize open purchase orders from which division stockmen can procure inventory.
- Users must police their own actual use of inventory.
- Set up training standards for Stockman.
  + How to purchase and shop around.
  + How to utilize SIMS system.
- Develop standard functional operational procedures for divisional Stockman - a manual of operation for stores for everybody.
- Modify the requisition form or stock numbering scheme for signs to allow for right and left indication.
- Simplify forms and reduce paper work.
- Eliminate credit card purchases of gasoline. Use of credit cards is rampant; purchase slips are not turned in for timely recording and oil company billing can be as much as two months in arrears. Instead, require gasoline to be expensible item to be borne by the employee and reimbursed by the Department.
  + Install no lead pumps at divisions to reduce credit card use or replace regular pumps with no lead.
  + Issue credit cards to individuals not vehicles.

4. Informational

More timely turnaround of information and feedback to the User Bureaus and Division Stockmen predominates.

- Communicate stock number assignments to division stockmen.
- More summary management information is needed regarding inventory usage.
  - \+ Location of inventory (the new system has this capability but it is not being utilized)
  - \+ How much it costs
- Provide Divisional Stockmen with financial cost information and inventory location.

5. Support Systems

a. Stores Inventory Management System

Several enhancements have been specifically identified.

- Include information on stock turnover rate, inventory value, price, reorder levels, optimum order quantities.
- Interface with ancillary systems of Equipment Management and Maintenance on a daily basis.
- Provide more inventory management information to the field.
  - \+ Unit prices.
  - \+ Onhand value.
  - \+ Reorder point exception list.
- Reduce duplication of items in the data base.
- Speed up data entry function.
- Increase availability of terminal to inventory coordinator.
- Simplify system's use. Make multi-function programs single function. Increase number of programs if required.

- Supply stockmen with a list of standard suppliers (vendors) for stock items so that items may be obtained timely within state guidelines.

IV. RECOMMENDED SOLUTION

The consensus of the committee is that the basic vehicle by which inventory is managed and reported is sound but that it must be allowed to work. The following enhancements have been identified which will make the system functional.

1. Organizational

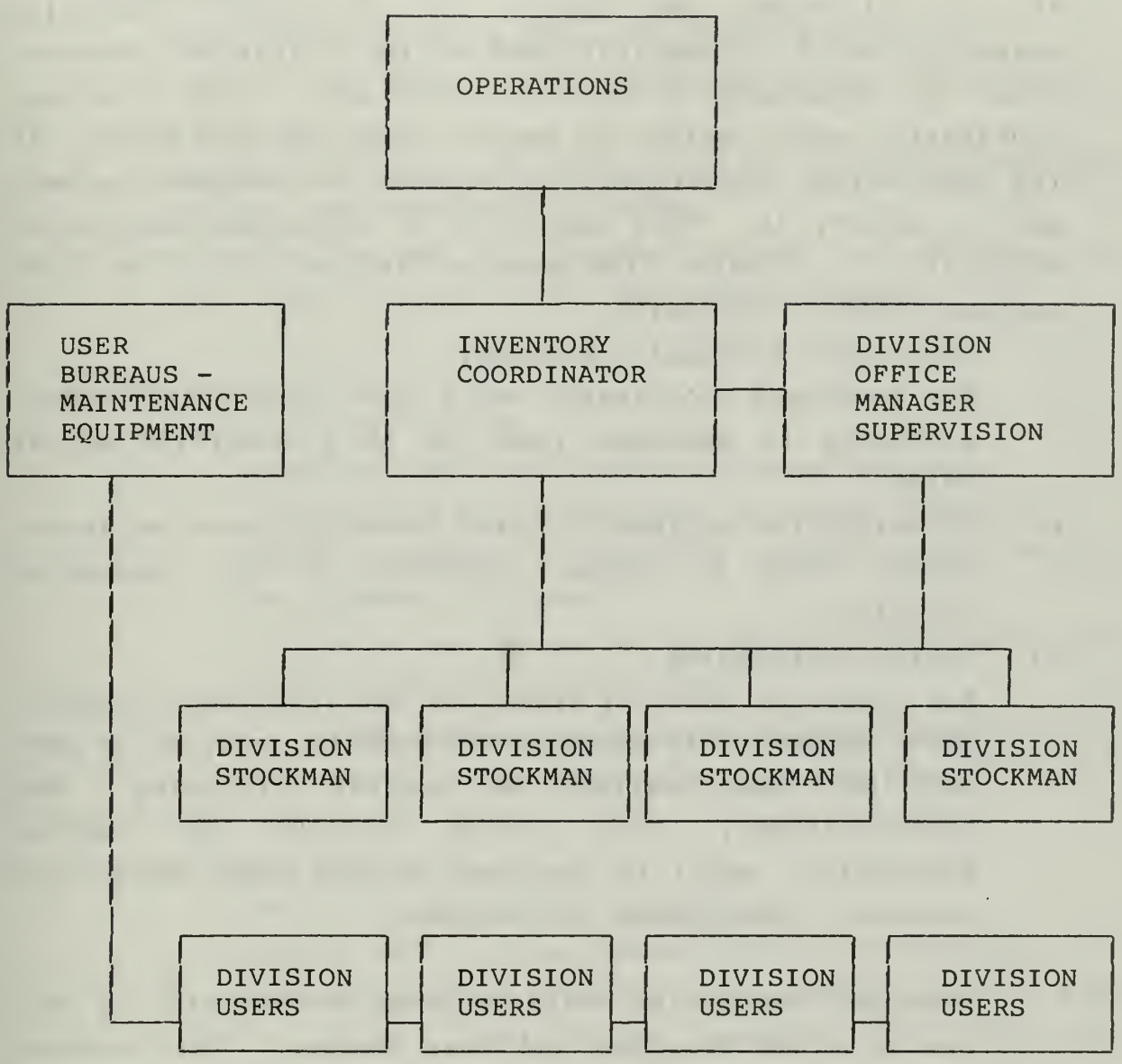
   The Stores Inventory Control function needs to be placed under one single line of authority and accounting entity. A suggested organizational structure appears in Exhibit 3. Stores would become a singular operation which would be responsible for maintaining optimal inventory levels for satisfying the supply needs of its User Bureaus - Equipment and Maintenance.

2. Operational

   User Bureaus, in conjunction with their Division personnel would establish their supply needs for the coming year. These budgets, along with identified items and anticipated usage schedule would be communicated to the inventory coordinator. It would then be up to the Inventory Coordinator to decide how to best serve the User.

   Divisional personnel would then become users of the Divisional Store. Divisional Stockmen would have the responsibility of providing for the daily supply needs of the Division. In instances where he needed to purchase items under a specified dollar value, for immediate use, he would have the capability of soliciting 3 verbal price quotations from local suppliers and after verbal purchase approval was received from the Inventory Coordinator, he would be authorized to acquire the needed inventory.

EXHIBIT 3


OPERATIONS
USER BUREAUS - MAINTENANCE EQUIPMENT
INVENTORY COORDINATOR
DIVISION OFFICE MANAGER SUPERVISION
DIVISION STOCKMAN
DIVISION STOCKMAN
DIVISION STOCKMAN
DIVISION STOCKMAN
DIVISION USERS
DIVISION USERS
DIVISION USERS
DIVISION USERS

Likewise, the Inventory Coordinator would have purchasing authority, under a specified dollar value. Items not on hand at the Division, and beyond the Divisions purchasing authority would be requisitioned by the Divisional Stockman from the Department's Central Inventory. The Inventory Coordinator would review the request with the User Bureau. If the User Bureau authorizes the request, he chooses the best way to satisfy it. That may be by a) Authorized purchasing authority, b) Transfer from another Division, or c) by going through Central Purchasing.

a) Authorized Purchasing Authority -
The Inventory Coordinator would have, at his discretion, authority to purchase items up to a specified dollar value.

b) Transfer from another Division Inventory could be transferred from a surplus location to the requesting Division.

c) Central Purchasing -
For items of value in excess of the Inventory Coordinator's authority to purchase he would be required to prepare Bid Specifications for Central Purchasing. Bid Specifications, after being detailed by Central Purchasing, would be reviewed by the User Bureau and Inventory Coordinator for accuracy.

Physical inventories would be taken periodically by both the Division Stockmen and User Bureau. The Stockmen would count those items still in Stores under his jurisdiction. User Bureau personnel would identify those items issued to them that are lying idle that could be returned to Stores for others' use. Exhibit 4 outlines these responsibilities.

EXHIBIT 4

- Stores Users
  - + Establishes yearly budget for needed supplies.
  - + Communicates anticipated level of service to Inventory Coordinator.
  - + Approves inventory purchases made by Inventory Coordinator that are over $500 in value.
  - + Monitors the use of inventory issued to his Bureau so that surplus items can be returned to Stores.

- Stores Operations
  - + Inventory Coordinator
    - Supplies user with inventory usage analysis.
    - Manages and trains Stockmen in stores operaton.
    - Makes purchases up to $2,000 in value after obtaining approval of User.
    - Initiates purchases with Central Purchasing and Coordinates detail with user.
      - Coordinates preparation of Bid Specifications with Central Purchasing and the User.
  - + Division Stockmen
    - Report to Inventory Coordinator.
    - Manage daily stores operation at the Division.
    - Have purchasing authority for inventory up to $500 in value with prior approval of Inventory Coordinator.

3. Informational

The recommended change is to provide the Division stockmen with the additional information itemized in Section III. The information can be easily provided by modifying the SIMS system as described below.

4. Support Systems

Based upon the ultimate organizational and operational changes that are implemented, the degree of changes desirable to the SIMS system will vary. At a minimum the following changes can be made to accomodate current procedures.

- Develop a functional users manual that is easily understood by stockmen.
- Provide operational information to the Divisions.
  - + Price
  - + Reorder levels
  - + Inventory value
- Reduce duplication of itmes on data base.

Additional information may be desirable for dissemination to the Divisions depending upon the level of accountability and responsibility given Division stockmen and upon the economy of providing the information.

5. Conceptual System Design

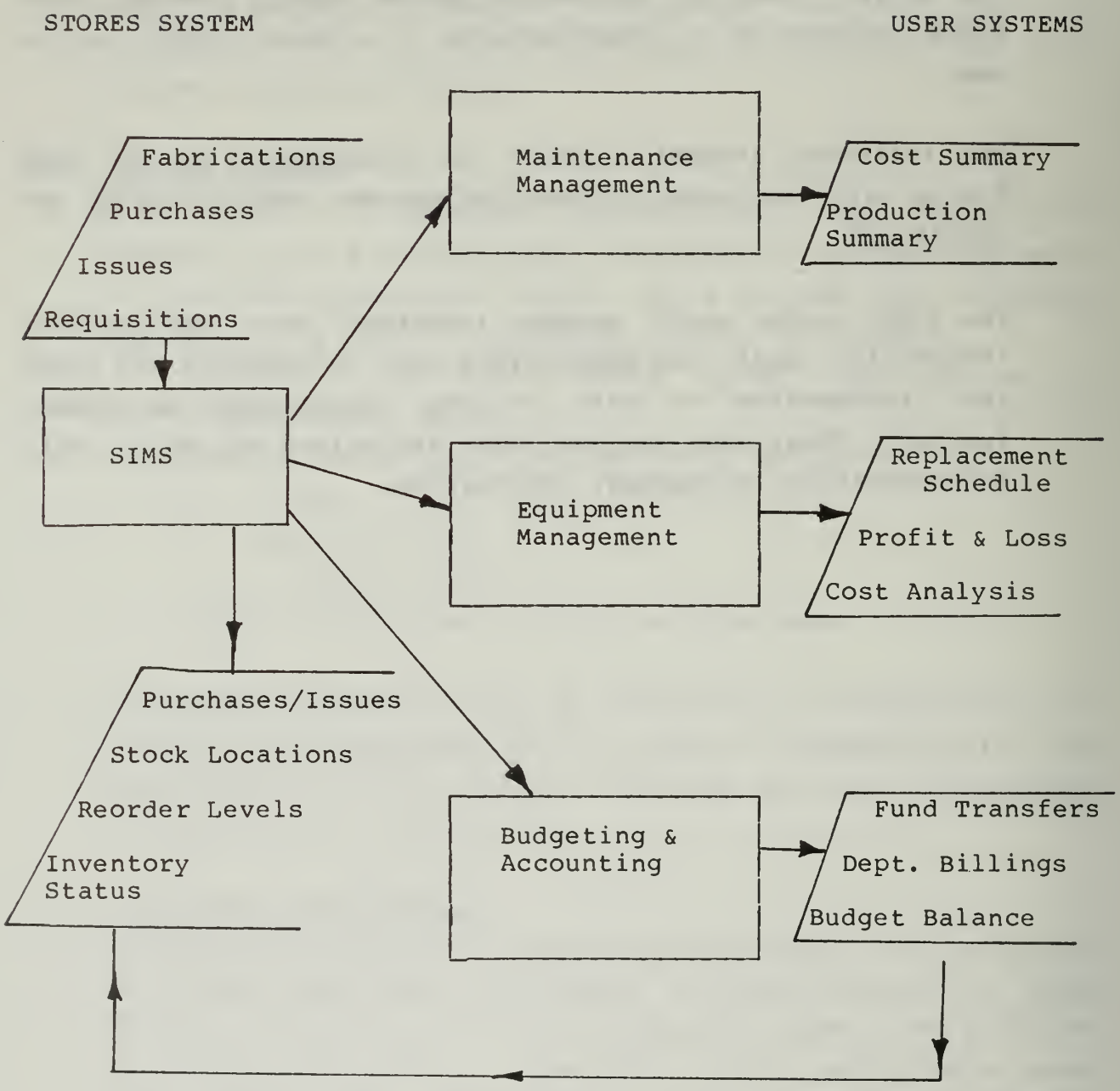
The perspective taken in developing this report has been from the stores operation. Equipment and Maintenance have been viewed as end users of the services and inventories supplied by a Stores Operation. Concurrent to this study there have been studies done specifically in the areas of Equipment Management and Maintenance Management. It is this author's opinion that those systems will provide fo the informational needs of stock usage in a manner meaningfully integrated with

the user's other cost information (labor, equipment, etc.). The Stores Inventory Management System should provide stock issue information to these systems in a manner timely to the user.

The following exhibit depicts the integration of the SIMS System with the other Information systems under study by the Department.

The SIMS system would process inventory issue and purchase information, apply the appropriate cost information and relay this information as data to the appropriate management systems. These user systems would assimilate the stores data into meaningful management information.

CONCEPTUAL SYSTEMS INTEGRATION



V. RECOMMENDED DEVELOPMENT PLAN

The recommended plan for the Department is to initiate a project for the purpose of developing an organizational structure and operational procedures for Stores Management and developing the supporting automated functions to augment those procedures. Thus, it is proposed that the project be divided into two (2) phases.

Phase I - Detailed definition & implementation of a stores management system.

Phase II- Detailed definition and implemention of automated SIMS system enhancements.

Operational procedures must be defined, accepted, and in place before the automated system can be enhanced. This phasing of development will allow new procedures to be proven effective and efficient and will reduce the potential for confusion and frustration which can result in bringing about too much change at the same time.

The following development Plan outlines the objectives and tasks of the project. The structure of project development should be carried out by Department staff in order to gain commitment to the system.

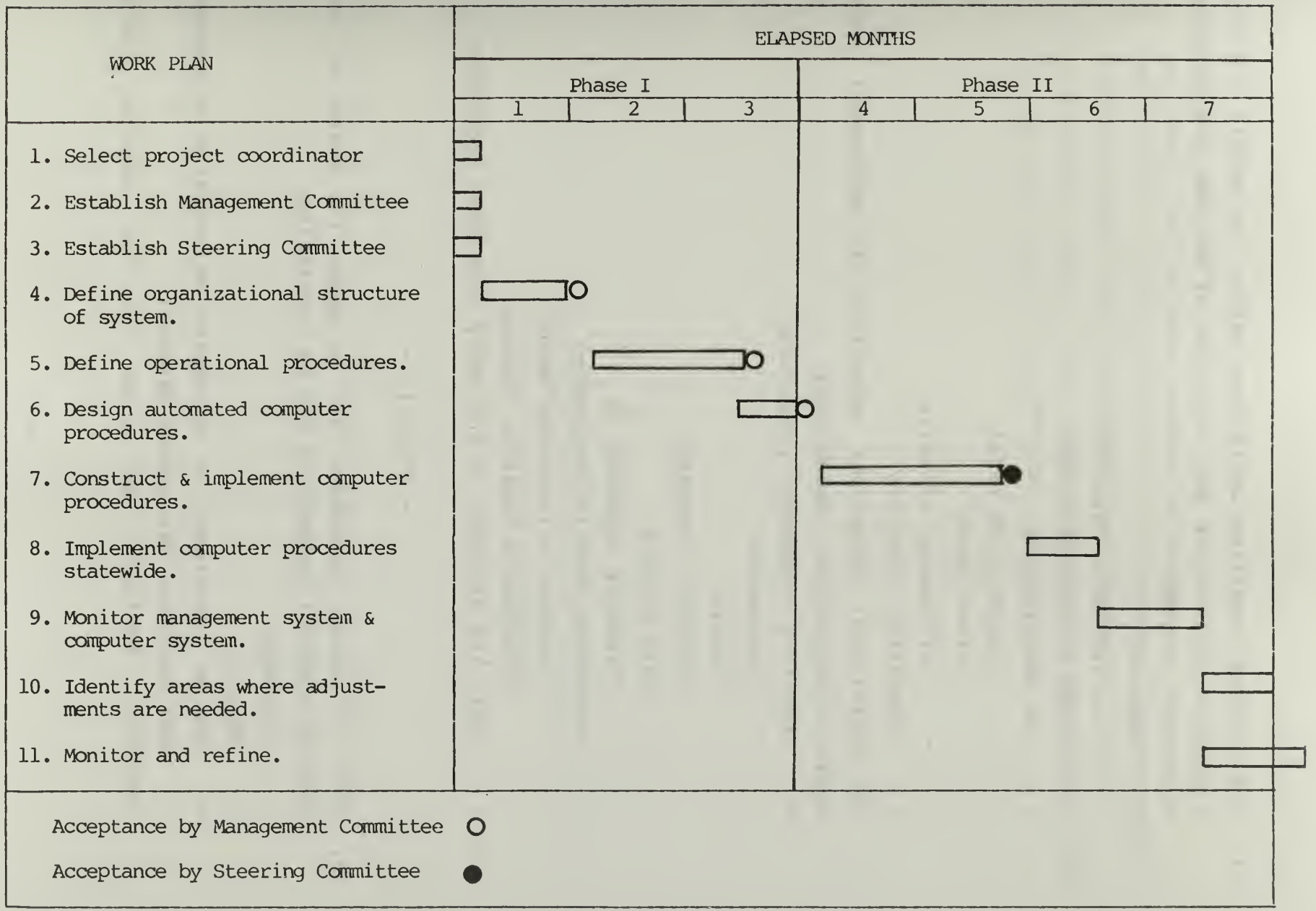
Work Plan Activities

The project activities required to restructure an Inventory Management System and enhance the existing SIMS information system are described below.

- Phase I -

Activity

1. Select a project coordinator/director to be responsible for controlling the project and shaping its final outcome.
2. Establish a Management Committee of upper-level members of Department management. This management committee has final authority for the project. It evaluates recommendations from its working arm, the steering committee.
3. Establish a steering committee of a cross section of inventory users, managers, and stockmen. This committee would be responsible for developing a comprehensive and workable Inventory Management System and presenting it to the Management Committee for approval. A data processing analyst would also serve on the committee. During the initial stages of the project his involvement would be in an advisory capacity. Care must be taken that the Management system developed accomodates the needs of those whose performance will be dictated by it and not the needs of a computer. Once the management system is developed and in place the data processing analyst will play a more significant role in interpreting the information needs of the Management System into data processing specific program development instructions.


WORK PLAN
ELAPSED MONTHS
Phase I
Phase II
1
2
3
4
5
6
7
1. Select project coordinator
2. Establish Management Committee
3. Establish Steering Committee
4. Define organizational structure of system.
5. Define operational procedures.
6. Design automated computer procedures.
7. Construct & implement computer procedures.
8. Implement computer procedures statewide.
9. Monitor management system & computer system.
10. Identify areas where adjustments are needed.
11. Monitor and refine.
Acceptance by Management Committee
Acceptance by Steering Committee

4. The working Committee would then define, in detail the organizational objectives and structure of the desired Inventory Management System.
   + Purpose
   + Organizational Structure
   + Areas of responsibility
   + Job descriptions
     - compensation level
     - career paths
     - performance criteria
   + Accounting integrity
5. The operational procedures supporting the management system would be defined and implemented.
   + Inventory Management procedures
     • Purchasing
     • Issuing
     • Physical Inventory
     • BID process
     • Transfer Requests
   + Procedures Manuals development
     • Stockman's Inventory Manual
     • Stockman's Training Program
   + Train the stockmen in the newly developed procedures.

- Phase II -

6. Once the manual procedures are in place, the design of supporting computer procedures can be identified.
   + Processes
   + Reports
   + System interfaces to automated Maintenance Management and Equipment Management Systems.
7. Construct, implement and pilot test the computer system

changes designed.

8. Implement the computer changes statewide.
9. Monitor the Inventory operations and computer system usage.
10. Identify areas where adjustments are needed.
11. Continually monitor and refine the management system until the optimal level of performance is achieved.

Costs and Benefits

The costs associated with developing a Stores Inventory Management System should be marginal in contrast with the other systems being considered. The automated information system for Stores is already in place and barring any changes in data processing philosophy or technology, the identified enhancements to it will not be costly. The major effort of the work plan identified involves the redefinition of procedures and responsibilities.

A preliminary estimate of effort required to develop a Stores Inventory Management System is 203 mandays. a detailed breakdown of the manday requirements by work activity is given in the following exhibit.

The benefits to be gained from improved Inventory Management Procedures far exceed the nominal cost of their implementation. Improved communications and efficiency of operations should optimize inventory levels to that indicated in prior studies.

MAN-DAY ESTIMATES

WORK ACTIVITY	Management Committee	Project Coordinator	Steering Committee	Data Processing	Man Day Estimate
Phase I	@3	@1	@6		
1. Assign Project Coordinator					
2. Assign Management Committee	1				3
3. Assign Steering Committee					
4. Organizational Structure	2.5	.5	5		38
5. Operational Procedures	5.	1	10		76
Phase II					
6. Computer Design		1	1	5 @ 1	12
7. Program Construction		3		30 @ 2	63
8. Program Implementation		1		10 @ 1	11
9. Monitor					
10. Adjust					
11. Refine					
TOTAL MAN-DAYS	25.5	6.5	96	75	203

Cost Summary

Project Team	Man Days	Daily Rate	Cost
Management Committee Administrators (3)	25.5	$150	3,825
Steering Committee	96		
Stockmen (3)	48	96	4,608
Inventory Coordinator	16	115	1,840
Accounting Analyst	16	115	1,840
Data Processing Analyst	16	115	1,840
Project Coordinator	6.5	115	750
Data Processing	75	155	11,625
TOTAL	203		$25,416

BH:mb:201G

VI. APPENDIX

STATE OF MONTANA
DEPARTMENT OF ADMINISTRATION
PERSONNEL DIVISION

POSITION DESCRIPTION

Personnel Use Only

1	Present Classification	Class Code	Classification Title (Current or Proposed) CHIEF, ~~INVENTORY BUREAU~~ PROPERTY MANAGER II	Grade 14	Position No. 43005
2	Agency	Department: Department of Highways	Division: Motor Pool and Equipment Division		
		Bureau: Inventory Bureau	Section: -	Unit:	
3	Address	City: Helena	Building & Street:	Room Number:	Business Tel.:
4	Personnel Division Use Only	New Title:	Class Code:	Grade:	Position No.:
5		☐ Desk Audit ☐ Field Audit	Effective Date of Action:		

6 General Statement of Duties and Responsibilities (Major duties and responsibilities of position)

Administer the Department of Highways 25 million dollar inventory system, coordinating all purchases, issues and disposition by the 11 field offices and Helena headquarters (includes Maintenance, Construction, Equipment and Accounting).

7 Specific Statements and Examples of Duties and Responsibilities (Itemized examples and specific statements)

1. Determine parts and supply needs of the Equipment, Maintenance, Accounting and Construction Divisions of the Department of Highways. This determination is based on a thorough and ongoing review and analysis of inventory records, prior year's requisition activities and estimates by the various Department stockmen& changes in policy and procedure as dictated by the various Division Administrators.

2. Monitors the requisitioning activities of each of the 11 Divisions and Helena Headquarters to assure that the proper types and quantities of parts and supplies are ordered. Responsibility of assuring that the requisition deadlines set forth by the State Purchasing Division's requisition time schedule are adheared to.

3. Maintains liaison and coordinates purchasing activities with the State Purchasing Division.

4. Advise Department stockmen as to the optimum levels of parts and supplies to be kept on hand.

5. Examines and determines the need for items on hand in each store's location that have not been requisitioned for use in a predetermined length of time. Length of time is dependent upon the specific item and is determined by the incumbent.

6. Review, approve and coordinate all proposed sales and transfers for excess parts and supplies statewide.

7. Reviews specifications on all items to determine their adequacy. Research and new specifications when deemed necessary.

8. Confers with the Administrator of the Centralized Services Division, Inventory and Property Control Section as to the changes in the commodity catalogs and inventory accountability problems.

9. Reviews the security and control measured taken at each store's location and makes recommendations for improvements.

Specific Statements and Examples of Duties and Responsibilities Continued.

10. Maintains liaison with suppliers in order to keep abreast of changes and new developments in various commodities.

11. Recommends and maintains policy, methods and procedures for statewide inventory control systems.

12. Investigates, researches and analyzes special projects as assigned by the various Division Administrators and Bureau Chiefs (e.g. Chief - Construction Bureau, Administrator - Maintenance Division).

13. Performs related work as required.

14. At the present time the Department is working with consultants in order to establish a computer oriented Inventory Control and Reporting System. This system initially will be concerned with a field inventory system via terminals in each of the 11 division (field) offices.

    Incumbent will be assigned the responsibility of supervising the statewide system including initiating and enforcing policy and procedure; recommending revisions to the same, etc.

8 Title and Number of Positions Supervised

Title	No.	Title	No.
Indirectly: division administrators, office managers, stockmen, etc. for the purpose of inventory control.			

9 Describe Nature of Supervision (How are work assignments made by incumbent; does incumbent review, approve, recommend approval of subordinates' work; does incumbent hire, recommend discharge, evaluate performance, etc.)

Supervision is exercised through written memorandum, procedure manuals, verbal instructions. Incumbent approves or rejects purchase orders, supply requisitions and disposition of inventory items.

10 Equipment or Machinery used

TYPE	%	TYPE	%
All general office machines on occasion,			
computer terminal.			

11 References, Manuals and/or Guides available to assist incumbent in performance of work (include statutes, regulations, etc.)

Department of Highways Accounting Manual
Department of Highways Cost Accounting Manual
Motor Pool & Equipment Regulation & Operation Manuals
Internal Policy and Procedure Memorandums
Vendor Specification lists, catalogs and brochures on equipment, supplies & parts.
Computer Inventory Control and Reporting Manuals

Technical Assistance Available (i.e. supervisor, specialists, etc. - how utilized, i.e. problem solving, planning, technical advice or review)

Administrator, Motor Pool and Equipemnt Division -- Problem solving, policy review & Planning

Administrator, Centralized Services Division -- general administrative guidelines

Administrator, Maintenance Division -- Problem solving regarding maintenance

Chief, Construction Bureau -- Problem solving regarding construction/maintenance needs and the everchanging requirements of items under inventory control

Work Assignment Methods and Procedures (How is work assigned to position; what form is it in (such as pencilled lay out, rough draft, etc.) and kinds of decisions already made.

Work assignments are normally verbal and goals are assigned. Incumbent determines priorities and methods.

Consequence of Error and How Errors are Discovered by Others (what are the ramifications of error, i.e. costs in dollars, public relations, service breakdowns, etc.)

Errors in judgment could result in loss of time and money. Oversupply of inventory items, obsolete items, incorrect items, and loss of time due to the seasonal nature of the work. Incumbent is assigned the responsibility and administration of a 25 million dollar inventory. Errors are reflected in budget overruns or excessive costs and unfinished or delayed work on projects.

Areas of Decisions and Commitments (Is the employee free to speak for the agency; can employee commit state, agency, or unit to a specific course of action - how is this accomplished?)

Incumbent is free to approve or reject requests for new inventory. Incumbent is responsible for determining if an item meets the specifications. Makes final decisions on most purchases and sales. Evaluates purchasing methods and practices.

ersonal Contacts (Type, nature, and frequency of contacts with persons outside of the agency)

	A	B	C	D	E	PURPOSE
nical Staff					X	general
fessional Staff				X		purchases
nagement Staff						
gency Directors, Chairpersons, etc.						
egislators						
rivate Sector Professional Staff			X			advice on equipment and supplies
rivate Sector Managers				X		review purchases on pending orders
eneral Public						
thers ( )						

A) Many times daily; (B) Once or twice a day; (C) Several times a week; (D) Several times a month; (E) Several times a year.

mments on Personal Contacts needing further explanation:

18 Working Conditions and Physical Demands. Explain physical factors which affect the position - use examples where appropriate.

Working conditions are good.

19 Supervision Level. Describe how position is supervised.

Supervision received is very general.

19A. Immediate Supervisor	Incumbent	Title	Class Code	Grade	Position No.
	Henry J. Dahl	Administrator, Motor Pool & Equip.	169070	18	01001

20 Minimum Education

Grade School					High School				College					
Ability to read & write	8	9	10	11	12	1	2	3	BA	MA	PhD
									X		

Specialization and Coursework. If specialized knowledges are needed to perform duties of the position, indicate minimum specialized coursework needed.

B.A. Business Administration or Accounting

21 Minimum Experience Required to perform Duties of Position:

Four years of responsible experience in inventory control and/or purchasing practices and management.

22 Special Qualifications (licenses, certificates, etc.)

23 Travel Required yes X no ____ ☐ Daily ☐ 2 to 3 times a week ☒ 2 to 3 times a month.

24 Knowledge, Skills and Abilities (Describe knowledges, abilities, characteristics, skills, etc. which are specifically job related and essential to perform the work of this position.)

Knowledges: Knowledge of equipment uses; whole Department needs and requirements for inventory items. Requires an incumbent who is knowledgeable in management procedures; purchasing practices and procedures. Abilities: Ability to coordinate a program involving many administrators. Ability to analyze and project the needs of rhe Department of Highways regarding all items classified as inventory. Ability to communicate verbally & in writ

25 Additional desirable knowledges, skills, and abilities that might contribute to outstanding job performance.

Thorough knowledge of the Department of Highways needs and requirements of an extremely wide variety of inventory items.

Signature of Agency Director	Date	Signature of Administrator, Personnel Division	Date
		L.A. Broughton, Admin., Hwy. Personnel Div.	(6/27/78

PBUFH057 13P1001 2702
PART NO: 13P1001 NOUN: ANTIFRZ DESCRIPTION: COOLANT SYSTEM

LOC	UI	OU	SC	VC	PRICE	ABC	ONHD	ONORD	MIN	MAX	ORDPT
2702	GL	GL		000001	3.1996	C3	101	0	60	180	90

CONTRACT NO: SLAMM STOCK NO: INITIAL DATE: 05/15/75
MFR NAME: SERVICE & SUPPLY MFR PART NO: 6850-0030-1

PURCHASED QUANTITY	AND AMOUNT	LAST COST AND DATE		VARIANCE
540	2363	3.1246	01/10/78	6%

OPEN ORDERS			USAGE				
MTD	QTY	DATE	YEAR	1ST QT	2ND QT	3RD QT	4TH QT	YTD
000000	0	00/00/00	77-78	171	276	183	0	630
000000	0	00/00/00	76-77	109	194	215	182	700
000000	0	00/00/00	75-76	0	0	103	134	237
000000	0	00/00/00	74-75	0	0	0	0	0

PBUFH057 09M1097 3201
PART NO: 09M1097 NOUN: CONTACT DESCRIPTION: IGNITION

LOC	UI	OU	SC	VC	PRICE	ABC	ONHD	ONORD	MIN	MAX	ORDPT
3201	EA	EA		000058	0.7611	C3	290	0	100	500	250

CONTRACT NO: 177234 SLAMM STOCK NO: 9-08 INITIAL DATE: 10/29/74
MFR NAME: ROX MFR PART NO: F1094MV

PURCHASED QUANTITY	AND AMOUNT	LAST COST AND DATE		VARIANCE
1030	2748	0.7950	01/09/78	16%

OPEN ORDERS			USAGE				
MTD	QTY	DATE	YEAR	1ST QT	2ND QT	3RD QT	4TH QT	YTD
000000	0	00/00/00	77-78	310	400	300	0	1010
000000	0	00/00/00	76-77	420	340	460	380	1600
000000	0	00/00/00	75-76	0	410	420	350	1180
000000	0	00/00/00	74-75	0	0	0	0	0

A position of Inventory Coordinator is recommended at the headquarters in Helena. This individual would review stocking levels, inter-division transfers, local purchasing, monies spent against open contracts, etc.

If possible he should be appointed as a purchasing agent for the Department of Highways with the authority to create purchase orders up to $5,000. He could also provide training for Division Stockman which would result in common procedures statewide.

- Facilities - Facilities, both at Helena and at the various Divisions, are not adequate to provide complete control of supplies. Stock is located in multiple storage locations, often at a relatively large distance from the main storeroom. The result is people waiting for the Stockman, people taking their own supplies, and often, difficulty in locating the Stockmen to issue parts and supplies.

  While it is recognized that facilities are poor, it is also recognized that only a massive rebuilding project could totally correct the problem. The problem will be reduced if the inventory levels are reduced, if the storage problems caused by annual purchasing and inadequate stock level control are eliminated, and if the stockmen themselves initiate a reorganization of the stock to maximize the facilities available.

- Yard Security - Currently there is uncontrolled access to inventory in the yards at some Divisions. Inventory can be brought into or taken out of the yards without the Stockman's knowledge, thereby bypassing inventory record updates and control. It is vital to maintain inventory record accuracy

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